ICAM Coalition Indicators Project: Literature review

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Draft 1.1
This is a draft literature review; a further manifestation of this document is being prepared for publication in a peer-reviewed journal

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2 Exec summary

This document summarises a review of 110 items of literature that included some aspect of initial assessment and/or monitoring and evaluation of dog population management (DPM) interventions, or methodologies used for an intervention on another species that could form a novel application to DPM. A total of 49 indicators are described, each one potentially reflecting changes in 8 impacts of which one or more could be stated as goals of DPM; for example improving dog welfare or reducing risks to public health. Alongside the discussion of indicators are explanations and critiques of the methods used to measure these indicators. The purpose of this review is to inform the writing of an ICAM Coalition guidance document on efficient and meaningful monitoring and evaluation of DPM interventions. The scope of this document is international, with a particular interest in simple, repeatable methods and meaningful indicators for communities searching for cost-effective impact assessment.

Not all indicators were found to be equal, varying in terms of their validity (ability to truly measure change in the impact they were supposed to be reflecting), reliability (whether repeated measures would produce the same result) and feasibility (can this indicator be measured with methods that are possible to perform in most locations). As a result a number of learning points relevant to the next stage of writing the guidance document were reached. These learning points are listed in the next section and throughout the document. In addition, the conclusion summarises the judgement made on each indicator and summarises the applicability of the methods of measurement to DPM.

3 Key learnings to inform guidance document (see also 6. Conclusion)

The following is a list of the key learning points reached through the literature review. Each one is hyperlinked to its position in the review; the context to each learning point will be included in the text immediately preceding the point. The points have also been grouped by the section header they fall under.

Improve welfare

1. Most common indicators of roaming dog welfare were body condition score and skin condition, probably because they are very visible signs and do not require clinical examination to be scored. Few other welfare indicators have been tested for their ability to measure impact of an intervention. However the scoring systems used for these indicators do vary between studies, a universal scoring system could be beneficial for comparisons between locations.
2. Indicators can be measured by more than one methodology yielding potentially differing results (e.g. prevalence of transmissible venereal tumours (TVTs), measured during street counts versus at the time of neutering when TVTs not externally visible would be included). Hence comparisons within project over time and between project should take heed of the methods used and compare indicators measured using the same method.
3. Behavioural indicators of welfare in roaming dogs have very rarely been tried and yet this approach is extremely common for measuring farm animal welfare. Developing reliable methods of measuring roaming dog behaviour and identifying key behavioural indicators of welfare and public safety (e.g. aggressive encounters between roaming dogs and members of the public) seems a fruitful endeavour for the guidance document.

Reducing/stabilising population size/density

4. Questionnaires of general public or dog owners are rarely used in monitoring (cohort studies are an exception to this) and are more commonly used for in-depth initial analysis to inform planning, perhaps due to the high resource investment in conducting/analysing/interpreting questionnaire results.
5. Most questionnaires reported the indicator of dog:human ratio as 1dog:*X*humans as opposed to, the arguably more intuitive, number of dogs for every 100 humans.
6. Survey methods that engage volunteers may shorten survey time and may also engage more people in subsequent planning and implementation of the intervention. But this needs to be balanced with reduced accuracy unless there is sufficient prior training.
7. Establishing absolute dog population size requires more intensive survey methods than measuring a relative index. Hence the need for an absolute indicator should be carefully considered as it may incur increased cost, lead to limited survey areas and a decreased chance of the survey being repeated. One possibility is to only pursue an absolute indicator as a baseline and monitor using a relative index.
8. Street surveys seem more commonly used for monitoring the impact of an intervention than questionnaires, perhaps due to the their resource efficiency and the fact that they specifically measure roaming dog populations which are more likely to be included in the impacts of an intervention than owned dog population size per se.
9. Percentage of lactating females may be a more reliable measure of breeding in roaming dog populations than percentage of puppies seen.
10. Although mortality and fecundity appear to be good indicators of population turnover, estimating these demographic factors with good longitudinal data from cohort studies can be difficult. In comparison age structure is relatively straight forward to measure, display and analyse from a point sample and so may be a more accessible indicator of turnover.
11. Immigration has rarely been included in the literature and yet when it is studied it appears to be very influential on population size (note this may become less important as the size of the study area increases). When exploring acquisition by owners subsequent questions about the source could be asked; local versus outside the intervention area.

Improving care provided to dogs

12. When using questionnaires to ask about care provided to dogs consider asking a question that explores whether a behaviour has been performed or not. Avoid questions that ask the owner to make a judgement whether they provide care 'regularly' or 'often' and ask instead if a behaviour has been performed in a set-time frame – e.g. "did you feed your dog yesterday?".
13. Participatory research methods could provide alternative ways of measuring indicators relating to dogs; although relatively new to dog research this approach appears to have worked well for impact assessment of working equines interventions (and many human development interventions).

Reducing risks to public health

14. Measuring the impact of an intervention on rabies risk is ideally achieved via measuring a combination of three indicators; dog bites, dog rabies cases and human rabies cases (plus vaccination coverage to establish attribution of the impact). With rabies cases confirmed through laboratory tests and 10% dog rabies case detection. However, this will not be possible in all locations and hence this should been seen as an ideal and any attempts at monitoring encouraged (do not let the perfect be the enemy of the good!).
15. Appropriate method of measuring vaccination coverage (an indicator of effort not impact) will depend on ownership status of dogs and whether vaccination is likely to have been done

through services other than a campaign that marked dogs at the time of vaccination (e.g. private veterinarians). Where dogs are majority owned but also usually free-roaming, a combination of (majority) 'resource-light' street surveys recording proportion marked and (minority) 'resource-heavy' questionnaires, where street surveys report below but close to target, may be most efficient. We need to establish key questions (probably focused on mark loss, vaccination of confined dogs and vaccination through other services) in order maximise questionnaire data as a means of validating estimates of vaccination coverage from street surveys of marked dogs. Need to consider how to establish the breakdown of the population into owned/unowned first in order to select the correct method of measurement.

16. Shorter timeframes for exploring number of dog bites seems ideal for revealing impact as soon as possible, e.g. when using a questionnaire as a method of measurement post the question "have you been bitten in the last year?" This may also avoid issues with poor recall over longer time-frames.
17. Reporting bite incidence per 100,000 people appears sensible for the developing world where urban growth is particularly large and so human populations within hospital catchments may increase rapidly – ideally an estimate of hospital catchment would be needed for every year of bite data.

Improve public perception/satisfaction

18. Some human behaviour indicators mentioned previously in relation to other impacts may also be useful for reflecting a change in public perceptions (e.g. adoption of street dogs and positive/negative interactions between street dogs and members of the public).
19. Asking questionnaire respondents for their level of agreement with attitude statements can reveal their perceptions of dogs. Providing a balance of both positive and negative statements may help to avoid biasing responses; order of presentation will also be critical. Further open questions about key attitude statements may increase the sensitivity of the indicator to change; although no test of this could be found in the dog literature.

Improve rehoming centre performance

20. Annual live release rate is a well-accepted indicator of centre, and community comprised of several centres, rehoming/adoption performance. Additional indicators of intake rate, net rehoming rate (incorporates returns) and footfall (plus a ratio of net rehoming:footfall), and time spent in the centre may well be useful for measuring centre performance in more detail, in particular for centres where their policy of non-destruction will lead to a stable 100% live release rate.

Reduce negative impact of dogs on wildlife

21. The number of predation events by dogs alone is not sufficient to assess the true impact of dogs and whether this is changing over time. The impact on the wildlife population size and structure should be measured along with the presence of dogs in wildlife areas/number of kills observed.
22. Surveillance of disease in both dogs and wildlife species will be needed to assess the impact of disease interventions; this may require initiatives to increase surveillance efforts and integration between dog and wildlife stakeholders.
23. Blood sampling for antibodies to canine distemper virus will only be useful if conducted over the long-term and across age groups to understand disease epidemiology. If an intervention includes vaccination it should be noted that vaccination itself will also produce a positive blood result for antibodies.

Methods of measurement

24. Cohort studies are very intensive but provide almost unique information about dog demography. Perhaps small scale cohorts could be followed to expose some of the otherwise invisible processes; alternatively including dog related questions in human focused cohort studies.
25. Questionnaires are commonly used for initial assessment of dog populations and their owners but not for evaluation as they are time consuming to implement and analyse. There are some questions and phrasings that lend themselves to evaluation. Providing project implementers and evaluators with advice on these questions and tools to reduce resources required to complete them seems useful for the project.
26. Reducing data from the indicators into a single score for each DPM intervention may be a step too far. However reducing data collected on indicator to a single score for each impact may help in presenting a large amount of data in a digestible form but will retain the different meanings of the impacts (e.g. a score for dog welfare, a score for public health and a score for public perception). Subsequently change could be presented in terms of % change for an impact score or just a traffic light system for positive, negative or no change.

4 Introduction

4.1 Background

The International Companion Animal Management (ICAM) Coalition Indicators project aims to develop guidance on monitoring and evaluation of Dog Population Management (DPM) that supports academics, practitioners and funders to track progress, learn and subsequently improve their DPM impact through the use of measurable indicators. The focus is on applying scientific solutions to real world problems and catalysing an increase in scientific research on DPM; our scope is international, with a particular interest in simple, repeatable methods and meaningful indicators for communities searching for cost-effective impact assessment.

Monitoring and evaluation (M&E)
Monitoring is the measurement of indicators that reflect progress towards targeted impacts of an intervention. It also includes measurement of intervention effort and relevant factors in the external environment. Evaluation is the use of data provided through monitoring to explore cause and effect and therefore test theories of change. Evaluation supports implementers to learn how to improve the efficacy and efficiency of achieving desired impacts.

Definition	**DPM example**
Impacts are the changes we hope to contribute towards through our interventions	Improve the welfare of roaming dogs
Indicators are measurable signs of impacts (also known as **metrics**); they are the things we would see or hear if our desired impact was occurring	Decrease in the % of dogs with emaciated body condition (can include baseline, target and timeline)
Methods of measurement are the methods we use to measure our indicators	Body condition scoring of all roaming dogs observed on an annual 'street' survey

The use of standardised indicators allows the achievements of many interventions to be compared and, through systematic reviews, can provide insights to inform policy and practice. However the development of standardised indicators requires validation across several locations to test whether these indicators are true reflections of change in targeted impacts. Such validation has not yet been achieved in DPM and hence the ICAM Coalition will develop **recommended** indicators and methods of measurement that have been shown in previous studies to be practical and appear to be sensitive to change in targeted impacts. Repeated use of these recommended indicators, along with welcomed innovations to improve these indicators, will in time develop sufficient data to allow for validation. As such we are developing best 'yet' practice in monitoring and evaluation of DPM that will be subject to updates.

4.2 Literature review objectives

- To provide a foundation for the guidance document by establishing important learning points (summarised in Exec summary and also in the Conclusion)
- To identify indicators and methods of measurement already used in baseline assessment or to evaluate the impact of an intervention on dog populations.
    - Highlight those that may be particularly suited to resource limited communities and free roaming dog populations (both owned and unowned)
- To identify indicators and methods of measurement being used in other species/fields that could potentially be applied to dog populations but have received no/limited attention to date.

4.3 Literature review assumptions

During the literature review a number of assumptions were made:

- We are most interested in indicators of effective outcomes/impact, as opposed to indicators of the input/effort we put into our interventions (however implementers must be aware that they should keep track of their intervention expenditure to allow for thorough assessment of return on investment)
- We are looking for indicators and methods of measurement that are especially cost-effective, as we are focused on locations that are resource (time and money) limited
- Establishing indicators and methods of measurement that suit monitoring within projects over time is our priority. However in the long-term, we are interested in making comparisons between projects, allowing us to explore magnitude of effect with different interventions; recognising that one intervention does not suit all and the characteristics of individual locations/dog populations must be taken into account

5 Literature review

5.1 Summary of literature reviewed

Literature search method was primarily snowballing; starting with known relevant publications and following citations (within and of those publications) that appear relevant. Starting with presentations and associated publications from the 1st International Dog Population Management Conference in York in September 2012. Followed by database searching with the terms dog*, canine* and population*, welfare, health (Pubmed, Science Direct, Google Scholar). In addition unpublished reports and publications were collated from members of the ICAM Coalition, the electronic consultation of the FAO and experts in the field of DPM or dog research. 'Literature' is hence defined as peer-reviewed publications, unpublished reports, conference presentations (oral and poster) and personal consultations.

110 items of literature were reviewed in total, 89 are cited in this review. Of these citations 67 (75%) focused on dogs, 9 (10%) on wildlife, 5 (6%) on farm animals, 5 (6%) on humans and the rest on cats, equines or a mix of species. 55 (62%) items of the literature were peer-reviewed, 15 (17%) were reports and the remaining were presentations and personal consultations. Less than half the literature attempted to evaluate the impact of an intervention, the majority were research into the number, demography, health and ownership of dogs that could be used as a baseline in later monitoring and evaluation of an intervention.

The methods of measurement described by the literature were varied and often several methods were employed within one study. The methods included questionnaires (commonly structured as Knowledge, Attitude and Practice KAP surveys), participatory research methods, street dog surveys, health assessments of dogs recruited to an intervention and analysis of data from secondary sources. There were also some papers that were reviews of several studies and a small number of guidance/policy documents that included advice on monitoring and evaluation.

5.2 Dog focused literature

The following section summarises the literature that focused on dogs. It is structured according to the targeted impact that was measured by the evaluation or, in the case of literature that described assessment only, the impact that *could* have been measured by the indicators if repeated. i.e. an assessment that included the indicator body condition score could be used to evaluate the impact of an intervention on dog welfare. Eight impacts and 49 associated indicators are covered in this section:

Impact	Indicators reviewed
Improve dog welfare	Body condition score Visible skin condition External parasites; fleas and ticks Open wounds Transmissible venereal tumours Canine infectious diseases Levels of cortisol Fetal resorption and litter size Dog-dog aggression Play behaviour Dog-human interactions (positive and negative) Qualitative behaviour assessment
Reduce/stabilise dog population size/density/demography	Estimates of absolute dog population size/density (e.g. total no. dogs, dogs per km^2) Relative indexes of dog abundance/density (e.g. number of dogs on set routes or dogs per km street surveyed) Dog:human ratios (or dogs per 100 people) % lactating females % puppies Estimates of mortality Estimates of fecundity Age structure Immigration Ratio males:females
Improve care provided to dogs	Performance of specific dog care behaviours Acquisition of dogs; proportion adopted proportion of the dog population that was confined for all or part of the day Increase in purchase of pet food Owner engagement in the intervention Owner willingness to pay for services
Reduce risks to public health	Number of dogs bites or post-exposure treatments (PET) provided Number of dog rabies cases Number of human rabies cases Number of dog bites (regardless of PET)
Improve public perception/satisfaction of dog health/welfare/risk/nuisance	Various attitude statements each potentially an indicator Summative acceptance of dogs score Prevalence of feeding ownerless dogs Adoption of dogs from the street Dog-human interactions (positive and negative) Reported number of type of problems caused by dogs
Improve shelter performance	Annual live release rate (euthanasia rates) Intake rates Net rehoming rates Footfall Net rehoming:footfall ratio
Reduce negative impact of dogs on wildlife	Presence of dogs within designated wildlife areas Number of observed wildlife kills by dogs Population numbers and structure of wildlife prey Incidence rate of rabies/CDV in both dogs and susceptible wildlife species Proportion of the dog/wildlife population with CDV antibodies
Reduce negative impact of dogs on livestock	Number of livestock predation events by dogs

5.2.1 Improve dog welfare

The impact of improving dog welfare and the impact of reducing/stabilising population size/density (described in the next section) was measured by the greatest variety of indicators within the reviewed studies. Indicators for measuring dog welfare can be split into those focusing on physical health and those looking for behavioural signs of psychological wellbeing.

5.2.1.1 Physical health indicators of dog welfare

Physical health was most commonly measured by **body condition score** (Sankey et al. 2012; Czupryna et al. 2012; Garde et al. 2012; Steinberger 2012; Yoak et al. 2013; Totton et al. 2011; WSPA 2007; Morters n.d.) and was found to improve following intervention in all cases where it was used in evaluation (Sankey et al. 2012; Steinberger 2012; Yoak et al. 2013; Totton et al. 2011). Body condition scales used were either the 9-point Purina scale (see appendix 1) that has been validated by Laflamme (1997) or a simplified 5-point version of this scale (see appendix 2 for an example used by WSPA) which has not been validated. Interestingly, the full 9-point scale was not always used in later analysis, with at least 2 examples of the data being collapsed into a smaller number of categories (Yoak et al. 2013; WSPA 2007) including just emaciated (category 1 and 2 in the 9-point Purina scale or category 1 in the reduced 5 point scale) compared to non-emaciated dogs (WSPA 2007). Inter-observer reliability was rarely mentioned, usually because all measurements were conducted by one experimenter, however Michelle Morters did use several people to assess body condition score and utilised a training session at the outset of her study and refresher one day training at the start of each census. She also asked two enumerators to score each dog's body condition independently of each other and then used the maximum and minimum scores in her model (*ask Michelle if she formally tested for agreement between observers*). None of the studies reported a relationship between body condition score and lactation but presumably one does exist. Anecdotally, lactating females are significantly more likely to have low body condition score due the high energetic costs of lactating but may return to their previous good condition quite quickly after puppies are weaned. Whilst data relating to lactation and its impact on body condition scores in roaming dogs is lacking it would be prudent to exclude lactating females from analysis of population level body condition scores. Similarly puppies are best scored with a puppy specific body condition score system, an alternative is to exclude puppies from analysis of population level body condition scores so that these relate only to adults.

The presence of a visible **skin condition** was also a relatively common indicator for physical health (Sankey et al. 2012; Garde et al. 2012; Steinberger 2012; Totton et al. 2011; WSPA 2007); this was found to differ following intervention on all occasions where it was used in evaluation (interestingly with a negative impact following ABC, i.e. more skin conditions seen, found by Sarah Totton et al. (2011)). This was usually simply presence or absence of a visible skin condition without any attempt at further diagnosis, any sign of hair loss or scaly/sore skin was counted as a skin condition. Sarah Totton also initially included elbow keratosis (thickened skin at the elbows) and skin tumors but later removed these two from the definition because the cause of keratosis may not have been related to the intervention and skin tumors may have been confused with other non-skin related conditions (e.g. hernias). Ruth Steinberger (2012) also describes a reduction in 'serious mange' defined as 'large areas affected and/or bleeding', suggesting that they used more than 2 categories or a scale of severity.

Learning point – Most common indicators of roaming dog welfare were body condition score and skin condition, probably because they are very visible signs and do not require clinical examination to be scored. Few other welfare indicators have been tested for their ability to measure impact of an intervention. However the scoring systems used for these indicators do vary between studies, a universal scoring system could be beneficial for comparisons between locations.

Related to skin conditions was the presence of **external parasites: fleas and ticks**. Obviously this could not be measured using observation alone and instead was measured via clinical exam of dogs as they passed through the intervention in two studies in India (Yoak et al. 2013; Totton et al. 2011). In both studies just the presence or absence of external parasites was used as opposed to any measure of abundance. The incidence of ticks was not used in evaluation of the intervention by Sarah Totton, but was used for evaluation by Andrew Yoak who found a greater proportion of the dogs with ticks in cities undergoing Animal Birth Control programmes ('ABC' programmes involving catching, sterilising and vaccinating and then returning stray dogs) as compared to an un-intervened city; although the incidence of a tick-borne disease was lower in ABC cities suggesting other factors were important in ehrlichiosis. Andrew Yoak also looked at the prevalence of fleas and found this was far lower in ABC cities as compared to non-intervened cities, interestingly he suggested fleas are a more sensitive indicator of dog health as they are opportunistic parasites and were in general only found on dogs that were sick (Andrew Yoak, *pers comm*).

The presence of **open wounds** was also used in evaluating ABC in the same two studies in India; the presence of open wounds was again measured during clinical exam (Yoak et al. 2013; Totton et al. 2011). Andrew Yoak found a significant and positive impact of ABC while Sarah Totton found no significant difference. Andrew Yoak felt that open wounds was a sensitive indicator of welfare during breeding season as he observed injuries inflicted during fights between dogs around females in 'heat', which were more frequent in the non-intervened city as compared to the ABC cities.

The proportion of dogs with visible **transmissible venereal tumours (TVTs)** was measured at the time of clinical exam as part of recruitment into a study in Chile by Garde et al. (2012); interestingly the level was very high at 12.8%. TVTs are also recorded during neutering by some interventions, as a proportion of TVTs are not externally visible the proportions recorded are presumably higher (Jack Reece *pers comm*). Similarly the proportion of dogs with visible TVTs during street surveys was recorded for a baseline study in Malawi for HSI (John Boone *pers comm)*, presumably without a clinical exam a much lower proportion would be noticed. This example of TVTs highlights the importance of clarifying the method of measurement used to measure the indicator, as different proportions of animals affected will be seen dependent on the method used.

Learning point – Indicators can be measured by more than one methodology yielding potentially differing results (e.g. prevalence of transmissible venereal tumours (TVTs), measured during street counts versus at the time of neutering when TVTs not externally visible would be included). Hence comparisons within project over time and between project should take heed of the methods used and compare indicators measured using the same method.

Perhaps surprisingly, the **incidence of canine infectious diseases** (other than rabies and TVTs) is rarely reported. Andrew Yoak's study in India utilised blood samples taken from dogs as they passed through the intervention, i.e. when the dog was already anesthetised for surgical neutering, and also from a sample of dogs caught in a non-ABC city that were rabies vaccinated at the time of taking a blood sample. From these blood samples he tested for antibodies (assumed to reflect infection as vaccination against these diseases is very rare in Indian street dogs) to several infectious diseases; leptospirosis, erhlichia and Infectious Canine Hepatitis (ICH) were found to differ in prevalence between locations; canine distemper virus, canine parvovirus and Brucella canis did not differ. Andrew Yoak felt that ICH could be a particularly useful disease to measure as it showed significant variation between locations (74% to 97%) and as a non-lethal disease was not overly affected by loss of dogs from the sample because they had died. The measurement of canine infectious disease incidence may also be more important in countries where the disease is not endemic but is emerging, e.g. erhlichia in the UK. *Note that measures of zoonotic infectious diseases (rabies, leishmania, echinococcus) are discussed later in the document under the impact of reducing risk to public health*.

There have been attempts to measure levels of **cortisol**, aka 'the stress hormone', in dogs. Urinary cortisol was found to be a particularly reliable method of measuring cortisol in kennelled dogs (e.g. Beerda et al. 1999) however urine samples only reflect cortisol levels over the preceding several hours. In comparison, cortisol levels in hair samples should reflect many months of cortisol release and therefore may be a better method of measuring chronic stress (Bryan et al. 2013), plus these hair samples can be taken through simple grooming or removing loose hair with a strip of Sellotape. However this indicator suffers from issues of validity, cortisol will also be high in dogs that are particularly active, so its use for measuring the stress levels in roaming dogs with varying and uncontrollable activity levels may be limited. In addition, the cost of analysing hair samples is 6-8 GBP, which is presumably too expensive for many of the locations this project is focused on.

Two indicators that were described as measures of reproductive health, but presumably could also be considered as measures of welfare, were **fetal resorption and litter size** (Totton, Wandeler, Gartley, et al. 2010). Sarah Totton examined uteri removed during an ABC programme in India, from the presence of placental site remains and autolysed tissue she was able to determine the number of fetal reabsorptions. Fetal resorption can result from disease, trauma, parasitism, toxins, stress, malnutrition and fetal abnormalities. It may occur in healthy dogs however there is evidence that it is more common in stray dogs than pet dogs (Totton, Wandeler, Gartley, et al. 2010) and also in heat stressed dogs (Ortega-Pacheco et al. 2007). Hence the presence of fetal resorption could be a measure of the welfare status of female dogs. Litter size and fetal resorption are clearly linked, with lower litter sizes at birth as resorption increases. Sarah Totton measured litter size again through uteri examinations, this time by counting the dark bands of the same width in the uterine horn, each band representing a previous placental site of a puppy, bands of the same width representing a single litter. Sarah Totton did not use litter size in her evaluation of the intervention and no studies were found that used litter size for evaluating female dog welfare. If examination of uteri is not possible an alternative approach could be to count litter size at, or shortly after, birth. However if the age of the puppies at first counting changed over time the litter size would also change, making this an invalid indicator of change in dog welfare.

Methods for measuring indicators of physical health included using observation only during a street dog survey; this was limited to body condition, skin condition, open wounds and visible TVTs. However several studies also used hands-on clinical assessments of dogs either as part of a study following a cohort of households and their dogs or as dogs passed through an intervention; this approach allowed for additional physical welfare measures to be taken including external parasites and the incidence of

canine infectious diseases, although this requires blood samples to be taken in addition to clinical examinations.

5.2.1.2 Behavioural indicators of dog welfare

Welfare is a comprised of both physical health and psychological wellbeing, hence behavioural indicators are measuring a relevant part of welfare that is not captured through physical indicators alone. Behavioural indicators of welfare have been used in several species and are arguably a better measure of emotional state, and therefore the animal's perception of its own welfare state, than physical indicators. Some behaviours may also not only be an indicator of negative emotional state but may be causing welfare problems themselves, for example aggression between dogs.

Although behaviour has been used to measure the welfare of individual dogs in kennels (e.g. Beerda et al. 1999) only one example could be found for measuring change in behaviour in roaming dog populations in response to DPM interventions (Garde et al. 2012). The following is a discussion of that study and others that have looked at behaviour in dogs that may be applicable to the DPM situation in future.

In Chile, Elena Garde and colleagues measured dog-dog **aggression**, dog-human aggression and inter-species aggression in roaming dogs (Garde et al. 2012), there was no clear impact of the intervention on behaviour but note that the intervention was limited to only castration of male dogs. They used video footage and later analysed the presence of different categories of behaviour in each 1 minute segment (0/1 behaviour analysis). Sunil Pal also measured agonistic behaviour in roaming dogs in India and found peaks in aggression between dogs around oestrus and lactation time (Pal et al. 1998). He used direct observation as opposed to video footage, behavioural data was collected ad libitum and focal-animal sampling (ref Altmann 1974 - *need to further explore this methodology*). Presumably if this population underwent DPM that included reproduction control of females these peaks in aggression would not occur as they were related to oestrus and lactation and would be reflected in the frequency of aggressive encounters between dogs.

At the opposite end of the scale to aggression, the presence of behaviours that reflect positive mental states could be used as a measure of good welfare, including amicable social behaviours such as allogrooming and play. **Play behaviour** in dogs has been used as a measure of welfare state in kennelled dogs (Rooney et al. 2009) and has been observed in young street dogs in India (Pal 2008). But no literature could be found on how this behaviour changes with an intervention.

The behaviour of dogs during **interactions with people** has been studied in pet dogs and shown to reflect previous treatment, with less play behaviour with owners and fewer approaches to new people performed by dogs reported to have been trained using punishment (Rooney & Cowan 2011). The response of street dogs to trained handlers is also being assessed in Jamshedpur, India (Joy Lee *pers comm*); dogs are scored according to their response to an attempt to pick them up by hand, on a scale of 0-5 with 5 being able to pick up the dog and 0 being an immediate aggressive response to the handler's presence. A negative response to a person is assumed to reflect a negative emotional state and/or a past negative experience with people. This measure of behaviour has not yet been used in evaluation of the impact of the intervention over time as it is currently being used only as a way of planning the intervention implementation (it allows an estimate of the number of dogs that can be pick-

up for neutering). As described previously, the interaction between dogs and people on the street was used in Chile (Garde et al. 2012) but not found to differ with the intervention. A measure of interactions between people and members of the public, both positive and negative, would seem a useful indicator not just of dog welfare but also of public safety and perception of street dogs. This has clearly not received sufficient attention yet to assess whether it would be sensitive to changes in the population following an intervention. But the proportion of negative interactions observed during interactions between farm animals and stockmen has been used as a welfare indicator and measure of improvement in stockman behaviour overtime (Hemsworth 2003), hence there may be ways of applying the methods to dogs.

One relatively novel approach to measuring behaviour is **Qualitative Behavioural Assessment (QBA)**, this has been trialled predominately in livestock species (Wemelsfelder 2007) but also has been trialled in dogs, specifically beagles interacting with an unknown person (Walker et al. 2010). The following description of QBA is a direct quote from Walker et al 2010 (pp 75):

> "Traditionally, establishing the welfare status of an animal is based upon behavioural and physiological measurement and evaluation. However, these methods tend to isolate particular aspects of behaviour for quantification, breaking up the behavioural flow and leading to a loss of 'whole-animal' information which cannot be regained at a later stage (Wemelsfelder & Lawrence 2001). Qualitative assessment of behaviour is based upon the integration of many pieces of information that, in conventional quantitative approaches, are recorded separately, or not at all. This may include incidental behavioural events, subtle details of movement and posture, and aspects of the context in which behaviour occurs (Wemelsfelder et al 2001). It focuses not so much on what an animal does, but on how it does it, that is, its dynamic style of interaction with the environment (Stevenson-Hinde et al 1980; Stevenson-Hinde 1983; Feaver et al 1986; Fagen et al 1997; Wemelsfelder 1997). Thus, behaviour is seen as an expressive process that is open to direct observation at any given moment in time, and that can be described using terms such as 'bold', 'shy', 'content', 'frustrated', 'bored' or 'relaxed'."

QBA has been validated in livestock species (Rutherford et al. 2012) and seems a relatively quick way to assess behaviour; e.g. observers are commonly advised to spend 10-20 minutes of observing groups of animals interacting with their environment before scoring them, which can take just 1-2 minutes. One significant positive outcome of QBA is that it encourages people to look at the whole animal and the way it interacts with its environment and assess its welfare holistically – in doing so this can increase empathy with the animal and very experienced veterinary inspectors have reported that it has altered their approach to welfare assessment, making it much more empathetic and presumably more accurate as a result (Francoise Wemelsfelder, *pers comm*).

The potential negatives of QBA are that it has not been well tested for its validity in measuring changes over time within one location; usually it is used to compare farms with each other. QBA is also inherently subjective and hence there are challenges of inter-observer reliability, although relatively short training sessions seem to have dealt with this problem in livestock (Phythian et al. 2013). The environment in which the assessor observes the animal may also bias their judgement, for example if they judge the environment to be poor they may perceive the animals in a more negative way. However this could be overcome to some extent by videoing the animal with as little as possible of the surrounding area in frame and then asking people to assess the dogs via video footage. More importantly the assessment is usually done by an independent assessor, which could be provided through representatives from ICAM who visit different projects on a regular basis but this does not support our aim to find methods that can be used by local project implementers. It has also not been well tested yet in dogs and not at all in roaming dog populations, so there is no information from which

a fixed list could be developed. In addition, the statistics used analyse the data produced from QBA assessments are relatively complex, tablet apps are now being developed to make this stage easier, but this could make its application in DPM projects difficult.

Learning point – Behavioural indicators of welfare in roaming dogs have very rarely been tried and yet this approach is extremely common for measuring farm animal welfare. Developing reliable methods of measuring roaming dog behaviour and identifying key behavioural indicators of welfare and public safety (e.g. aggressive encounters between roaming dogs and members of the public) seems a fruitful endeavour for the guidance document.

5.2.2 Reducing/stabilising population size/density

Impacting on dog population numbers is a commonly stated goal of DPM. This may be expressed as wanting to reduce population size (also sometimes called abundance) or stabilise population turnover (reducing births and deaths, with each animal living longer on average).

5.2.2.1 Reducing dog population size

Indicators for population size may be **estimates of absolute size** (for example the number of owned dogs living within in a city boundary) or **relative indexes of dog density** also known as 'index of abundance' (for example the number of dogs observed along a set of survey routes). Methods of estimating dog population size split into two broad categories of using household questionnaires to estimate owned dog populations or street surveys to estimate roaming dog populations.

Questionnaires usually ask for both the number of dogs and the number of people living in each household to establish a **dog:human ratio** which could then be used with census data of the human population to estimate the **absolute size of the dog population for a defined area** (Acosta-Jamett et al. 2010; Gsell et al. 2012). Other studies did not extrapolate to a dog population estimate but just provided a dog:human ratio as a relative measure of dog density (Knobel et al. 2008; Lunney et al. 2012). Two studies measured the physical area of the study site and used this in combination with the total number of dogs found through the questionnaire to calculate the **owned dogs per km^2** (Pulczer et al. 2013; Acosta-Jamett et al. 2010). Interestingly, rarely did studies use questionnaires to explore the impact of an intervention, they were all using questionnaires on a single occasion to investigate the dog population and how it related to factors such as geography and socioeconomic status of the owners; potentially providing a baseline for later comparison. One exception to this was Kitala et al. 2001 who utilised two questionnaire surveys one year apart to estimate population turnover in preparation for planning a rabies vaccination campaign, but again was using this approach for investigating a population ahead of intervention as opposed to measuring the impact of an intervention. The other exceptions are those few examples of cohort studies that utilise repeated questionnaires to track dogs living in a sample of households; Michelle Morters (South Africa and Bali) and Darryn Knobel (South Africa) have been using this approach to track the 'natural' changes occurring in an intervened population, whilst Anna Czupryna (Tanzania) and Chris Baker (Guatemala) have been following a cohort during intervention. The benefit of cohort studies will be discussed again in the following section on measuring dog demographics.

Questionnaires are relatively time consuming to design, implement and interpret, hence perhaps this methodology lends itself more to in-depth initial assessment and less to regular monitoring over time.

Learning point – Questionnaires of general public or dog owners are rarely used in monitoring (cohort studies are an exception to this) and are more commonly used for in-depth initial analysis to inform planning, perhaps due to the high resource investment in conducting/analysing/interpreting questionnaire results

It is interesting to note that these questionnaires all reported the dog:humans ratio as one dog to *X* number of humans (or presented the other way round as humans:dog). An alternative is to report the number of dogs for every 100 humans; this approach provides the same information but may be more intuitive as a larger number means more dogs, as opposed to the 1 dog: *X* humans where a larger *X* means fewer dogs.

Learning point – Most questionnaires reported the indicator of dog:human ratio as 1dog:*X*humans as opposed to, the arguably more intuitive, number of dogs for every 100 humans

Street surveys of roaming dogs were reported relatively frequently in the literature and several attempted to evaluate the impact of an intervention using indicators drawn from these street surveys (Sankey et al. 2012; Reece & Chawla 2006; Hiby 2012; Totton, Wandeler, Zinsstag, et al. 2010). The methods of measurement utilised in these street surveys fell into 4 categories of mark-resight, direct observation on set routes, direct observation of all streets within plots and point surveys:

- Several studies utilised **mark-resight** as part of their street survey methodology to estimate the **absolute size of the roaming dog population for a defined area**; this usually used marks applied as part of the intervention such as collars given during a vaccination campaign (Gsell et al. 2012; Kayali et al. 2003) or ear notches applied during anaesthesia for ABC (Hiby 2012). However there were studies that applied paint spray as marks as part of the survey process, with resight occurring the following or subsequent days (Totton, Wandeler, Zinsstag, et al. 2010; HSI 2013; OBHOYARONNO 2011) or naturally occurring marks and scars to identify individuals leading to 101 out of 371 dogs being identified in a pilot test of this method in India (Punjabi et al. 2012).
- One study reported the use of **direct observation on set routes** for establishing relative measure of dog numbers, specifically the **total number of roaming dogs seen on all 6 routes** (Reece & Chawla 2006; Reece 2012). No estimate of total dog population size for the wider area is drawn from these data, but the change in the number of dogs seen on these routes is presumed to reflect the change in the wider dog population density. This survey approach has been used once or twice per year for 16 years in Jaipur, yielding some excellent and entirely unique long-term data on dog density in response to an intervention.
- Three further studies utilised **direct observation during exhaustive searches of plots** (plots were either authority defined areas such as wards or boroughs or they could be specifically drawn for the survey to a certain suitable size). When these plots were sampled from a wider area of interest they could either be used as a relative measure of dog numbers, specifically the **number of roaming dogs seen per block**, by repeating counts in the same blocks over time (Sankey et al. 2012) or extrapolated up to provide an estimate of **absolute size of the roaming dog population for a defined area** (Ssuna 2012) using the proportion of this specific wider area covered by the

sample as a multiplier**.** However when the plot covered the entire area of interest this exhaustive search was effectively a census providing the an estimate of the **total roaming dog population size** (Boone 2013). It should be noted that these exhaustive searches were done at a particular time of day, usually in the early morning when dogs were found to be most active. Hence they are a measure of roaming dog populations in the early morning, which is likely to comprise much of the total roaming dog population but potentially not all if there is a significant proportion of the population that only roams at other times of the day. Turning this estimate of roaming dogs into an estimate of total dog population requires a measure of detectability – i.e. the probability that a dog that lives in this area will present on the street at the time of the survey. This was estimated to be 0.44 for dogs in Veracruz, Panama by John Boone 2013.

- One study was found that utilised **point counts** as a method of surveying, with the aim to measure the indicator of **absolute size of the roaming dog population** for the city of Detroit (World Animal Awareness Society, WA2S 2013) – (*please note – I am following up on some references for this survey approach as the analysis used is not described in the literature I have found to date, below is my current thoughts but this may be amended)*. This involves observers standing at a sample of points that are spread across the area of interest and recording all dogs they see within a certain timeframe, the population size is then calculated using some estimate of the area within which observers could see dogs. This is a commonly used survey method for birds, in particular during the breeding season when birds are likely to be more territorial, as the points can be spaced to avoid overlap of territories and double counting. However its use in dogs seems limited to this one study. This method may face challenges in its application to dogs; dogs are arguably not strongly territorial and are more likely to be socialable so double counting is more likely in particular when points are closely spaced; the radius of reliable observation will be very variable in an urban environment (consider the observable radius when standing in an area with high rises versus standing at a junction in a low-rise residential area); there are practical challenges in navigating to each point and also observers may lose motivation when repeatedly standing for 5 minutes with no dogs in sight (consider the psychology of an alternative of surveying along a route when you are constantly moving, only pausing to record a dog you see). The benefit of this particular use of point surveying was in the utilisation of a large number of volunteers (65) to ensure a large survey could be done in a short space of time (2 days) and also to engage more people in understanding the dog problem and hence in planning and implementing the subsequent intervention.

Learning point – Survey methods that engage volunteers may shorten survey time and may also engage more people in subsequent planning and implementation of the intervention. But this needs to be balanced with reduced accuracy unless there is sufficient prior training.

Kayali et al. 2003 is an interesting study because it combines mark-resight (marks applied at the time of mass vaccination campaign) with a household questionnaire, including recording if dogs within the household are marked, to estimate the owned and unowned dog population in Chad. The results are reported with relatively narrow confidence intervals, however simulation models suggest this level of reliability could only be achieved when a high proportion of the dogs are owned and a high proportion are marked (Lex Hiby *pers comm*); conditions that are perhaps achievable in many locations but not all. The same method was also used by Gsell et al. 2012 in Tanzania.

The methods of conducting street surveys differ in both their ability to measure absolute size versus a relative index and also in the time taken to conduct the survey. These two factors are linked, when absolute population size is desired the survey needs to be more intensive, at least for a proportion of the area surveyed; Boone & Slater 2013 describe using rapid surveys over a wide area to establish a relative index of cat population size and then intensive surveys in a smaller sample of areas to establish a detectability factor that can then be applied to the results of the rapid surveys allowing for an estimate of absolute size over the wider area. The intensive methods reported in the literature for dogs include mark-resight, exhaustive searches of plots and questionnaires where owners are asked about dog confinement. The need for an indicator of absolute size should be carefully considered, because it requires more intensive and resource heavy methods of measurement the survey will inevitably cover a smaller area, compared to what could be achieved with the same resources used for a method designed for relative index measurement. For example, the 6 set routes used by Jack Reece in Jaipur (Reece 2012) are completed in approximately 12 hours spread over 6 days compared to the 6 areas used for mark-recapture in Jodhpur by Sarah Totton (Totton, Wandeler, Zinsstag, et al. 2010) where each of the 6 areas required approximately 10 hours over 5 days, leading to 60 hours in total. In summary the mark-recapture approach takes 5 times longer to complete than the set route approach, which may go some of the way to explain why this Jaipur survey has been used at least once per year for 16 years and the mark-recapture survey has only been done twice in Jodhpur.

One additional comment on measuring absolute population size is that many of the methods used suffer from inherent methodological problems such as; mark-resight models reported for dogs assume closed populations including no immigration or emigration which is likely violated when using study sites of a small area, in addition they usually also assume equal likelihood of marking which probably will actually vary between dogs (there are models that allow for heterogeneity in sighting probability such as used by (Belsare & Gompper 2013); exhaustive searches of plots miss dogs that do not roam at the time of surveying; and owners may not be reliable in their estimation of confinement (or lack thereof) of their dogs. If these methodological problems remain constant over the period of intervention these indicators will still function for monitoring changes in population size over time; however they really should be defined as relative indices and not measures of absolute size. Which begs the question why invest so much effort in measuring absolute size if you are unlikely to really achieve this?

Learning point – Establishing absolute dog population size requires more intensive survey methods than measuring a relative index. Hence the need for an absolute indicator should be carefully considered as it may incur increased cost, lead to limited survey areas and a decreased chance of the survey being repeated. One possibility is to only pursue an absolute indicator as a baseline and monitor using a relative index.

Street surveys are relatively more resource light than questionnaires which may explain why they seem to be used more commonly for evaluation. In addition, by their very nature they measure the roaming dog population in some way and this is usually the population of interest for DPM. Rarely will a DPM aim to reduce the owned dog population size per se, potentially increasing some quality such as the care given to own dogs will be the goal, however reducing the *roaming* dog population size may be a goal on the basis of human safety or dog welfare risk.

Learning point – Street surveys seem more commonly used for monitoring the impact of an intervention than questionnaires, perhaps due to the their resource efficiency and the fact that they specifically measure roaming dog populations which are more likely to be included in the impacts of an intervention than owned dog population size per se.

5.2.2.2 Stabilising dog population/reducing dog population turnover

In some cases reducing dog population size may not be desired (this may only become apparent during consultation with local communities, whilst governments and NGOs may mistakenly assume there are 'too many' dogs) however reducing the turnover of the population may be a goal. A population with high turnover has high birth rates and high mortality rates, with each dog having on average a relatively short lifespan. The high mortality rate implies high morbidity and a poor state of welfare hence this indicator can also be used as a measure of dog welfare. High population turnover during a vaccination campaign also means vaccinated dogs die and unvaccinated puppies are born reducing herd immunity, so this indicator is also related to the impact on public health. The following are indicators that were reported in the literature as potentially reflecting changes in population turnover:

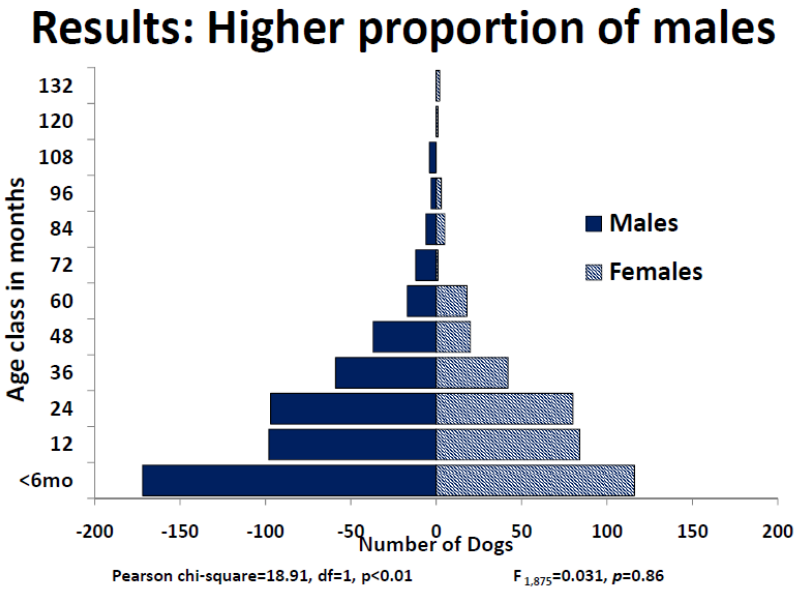
A change in the **percentage of lactating females** and the **percentage of puppies** seen during street surveys were reported a number of times during evaluation of interventions (Sankey et al. 2012; Sharma 2012; Jones & Lee 2012). It is argued that these indicators of breeding would be the first to be seen ahead of any change in dog population size as changes in size would only occur as dogs die and are not replaced at the same rate. It should be noted that puppies are more difficult to observe during street surveys as they are more commonly hidden from view, in addition they commonly appear in litters and so the data are clustered. Hence the percentage of lactating females may be the most reliable indicator of breeding. It should also be noted that breeding seasons do occur in some countries (Reece et al. 2008); hence % should be compared at the same time of year, or year round data should be plotted in advance to check whether seasonal patterns exist.

Learning point – Percentage of lactating females may be a more reliable measure of breeding in roaming dog populations than percentage of puppies seen

An estimate of **mortality** and **fecundity** (average birth rates per female) was reported in several studies. One method of measuring these indicators was using a questionnaire to ask dog-owners to report whether any dogs had left their household in the past 12 months and also whether their female dogs had reproduced in the last 1-3 years (Acosta-Jamett et al. 2010; WSPA 2007). One very simple way of analysing these data is to report the percentage of dog-owning households that report a dog dying in the previous 12 months, this was used in Thailand and showed a reduction following intervention (Lee 2013). Cohort studies used repeated investigations of dogs within the same cohort of households and could follow relatively reliably the birth and death rates of dogs (Morters submitted, Czupryna et al. 2012, Darryn Knobel *pers comm*, Chris Baker *pers comm*). Gsell et al. 2012 used questionnaire data to create 'life tables' (more commonly used in cohort studies), this was a relatively novel way to estimate mortality/survival from questionnaire data. However the equation used to calculated mortality assumes that the population was stable, which is violated by the reported 10% growth than is discussed later in

the paper. Finally Totton, Wandeler, Zinsstag, et al. 2010 fitted a demographic model to the data collected through street surveys, investigation of uteri during spaying and estimates of pregnancy in Jaipur to calculate mortality and fecundity for Jodhpur (*however I do not understand the model they have used to do this!*).

In general, mortality and fecundity are attractive indicators because they relate so closely to the concept of population turnover; however they are relatively difficult to calculate from the data and require a reasonable understanding of ecological theory and modelling. One alternative is to look at a point sample **age structure** of the population. Age structure can be presented in histograms, for example see the double histogram showing age structure split by males and females presented by Anna Czupryna (Czupryna et al. 2012):



It could be argued that a population with a high puppy:adult ratio is experiencing high population turnover, however an alternative explanation is that this population is in a period of growth which would have a very different meaning if you were hoping to use age structure to measure welfare. One way of tackling this is to also consider the older end of the spectrum, e.g. dogs aged 5 years or more. Researchers using cohort methodologies often mentioned the importance of 'golden oldies' or 'grey beards' in their populations. One option would be to use ratios of puppies:adults:old adults as an indicator of age structure on the assumption that a population that shows increasing weight in the old adult category as compared to puppies is a population that is decreasing in turnover and increasing in average lifespan which indicates better welfare. Measuring such an indicator can be done by using cohorts, questionnaires where people are asked the age of their dogs and also potentially through street surveys if a reliable definition of an old adult can be found (e.g. grey hairs on the muzzle). As with previously discussed indicators of % lactating and % puppies, ratios of puppies:adults:old adults should be compared at the same time of year to account for any seasonality in breeding.

Age structure was reported in a number of studies (Morters submited; Gsell et al. 2012; Acosta-Jamett et al. 2010; WSPA 2007; Totton, Wandeler, Zinsstag, et al. 2010; Czupryna et al. 2012) however was never explicitly mentioned as an indicator of the impact of an intervention on population turnover or

welfare. Interestingly, data from a 5-year cohort study in Guatemala are currently being analysed and changes in age structure as a result of an intervention will be explored (Chris Baker, *pers comm*).

Learning point – Although mortality and fecundity appear to be good indicators of population turnover, estimating these demographic factors with good longitudinal data from cohort studies can be difficult. In comparison age structure is relatively straight forward to measure, display and analyse from a point sample and so may be a more accessible indicator of turnover

Immigration is also a relevant factor in population stability, especially where imported dogs are of unknown vaccination status; consider a situation where the population appeared to be constant or even rising with reduced local birth rates but countered by increased immigration, suggesting that the intervention may have disturbed the balance of demand and supply in the local area beyond what was planned. Cohort studies that have measured immigration have found very high levels, for example at least a third of dogs in Bali and South Africa came from outside the study area (Morters submitted) and again in South Africa immigration was found to exceed birth rate in one town not currently subject to an intervention (Darryn Knobel *pers comm*). Despite the apparent importance of immigration very few other studies seem to mention it (*check MacDonald and Carr in The Domestic Dog*). One option for measuring immigration is to ask dog owners during a questionnaire for the source of their dog including whether it was locally sourced or from outside the area. One note of caution is that the answer to this question appeared to vary with respondent and over time in a cohort study in Guatemala (Chris Baker *pers comm*) and hence some measure of reliability, potentially through retesting a sample of households may be required.

Learning point – Immigration has rarely been included in the literature and yet when it is studied it appears to be very influential on population size (note this may become less important as the size of the study area increases). When exploring acquisition by owners subsequent questions about the source could be asked; local versus outside the intervention area.

One final indicator relevant for measuring population stability and potentially also welfare is the **ratio of males:females**. This ratio was reported in almost every study and always with males predominating; the assumption for this being a useful indicator is that litters are born 50:50 but there is disproportionate mortality in females potentially due to preferential adoption and care of males presumably because females are consider more a problem due to unwanted litters. One specific example of this was a greater number of females being sold to meat traders in Bali as compared to males (Morters submitted). It has also been suggested that females suffer greater mortality risks of reproduction not least due to the high energetic cost. However in India where the roaming dog population is assumed to be majority unowned the sex ratio is equal or close to (Reece & Chawla 2006; Totton, Wandeler, Zinsstag, et al. 2010). This suggests that a strong skews towards males is more likely where owned dogs predominate and people preferentially care for owned male dogs which are then allowed to roam and hence influence the ratio both in the owned and roaming dog data. Interestingly, if this is the case then sex ratio should be open to influence, for example by providing spaying of females to reduce the problem of unwanted litters. However there were only a handful examples of looking at male skew in response to an intervention and none of these found that the ratio differed significantly over time (Sharma 2012; Totton, Wandeler, Zinsstag, et al. 2010).

5.2.3 Improving care provided to dogs

For some interventions the desired impact will be an increase in the level of care provided to dogs and/or responsible dog ownership (which may be defined as good care plus efforts to reduce the risks dogs present to other animals, people, environment and contributing to good population management by not abandoning dogs and engaging in adoption. An improved level of care and responsibility may or may not be paired with the impact of actual dog welfare improvement, which is assumed to result from improved care.

The **performance of specific dog care behaviours** was almost always be measured through a questionnaire, either delivered as a face-to-face interview (e.g. Farnworth et al. 2012) or over the phone (e.g. Hsu et al. 2003). The specific care explored depended on the focus of the study but usually included feeding, water, shelter, aspects of veterinary care and confinement. One challenge with exploring care via owner interview is how the question is perceived, for example Hsu et al. 2003 asked whether owners took their dogs for 'regular check-ups' at the vet and Farnworth et al. 2012 asked people to rate taking their dog to the vet as 'often', 'sometimes' or 'never'. The challenge with this approach is that you are at least partially measuring the owner's perception of 'often' or 'regular'. An alternative is to ask people about their actual behaviour, for example Hsu et al. 2003 also recorded people who stated that they never took their dog to the vet. The following are examples of questions used to assess actual owner behaviour that with repetition could be used for evaluation:

- Was your dog vaccinated for rabies in the past 12 months? (e.g. WSPA 2007) Note the time scale of 1 year included in the question as opposed to just 'is your dog vaccinated?' (this is discussed further under the later indicator of vaccination coverage)
- How often do you take your dog to the vet? Category of 'never' reflects behaviour rather than the owners perception of appropriate levels of vet attention (Hsu et al. 2003; Farnworth et al. 2012)
- Did you feed your dog yesterday? (Morters submitted)
- Is your pet registered with a vet? (PDSA & YouGov 2012)
- Do you have insurance for your pet? (PDSA & YouGov 2012)
- Do you carry out any population control yourself? (or version of this question) For example Acosta-Jamett et al. 2010 found selective culling of female puppies in Chile; Hsu et al. 2003 found people who admitted to releasing or abandoning their unwanted dogs; whilst in Bali, selling dogs to the meat trader is a locally specific method of population control, found when asking about the fate of dogs that have left the household since the previously survey (Morters submitted)

The **acquisition of dogs** was also explored by several studies and in particular **the proportion of dogs that were adopted from the street** (Acosta-Jamett et al. 2010; Hsu et al. 2003; WSPA 2007). The study conducted on Kho Tao, Thailand, was particularly interesting as it tracked a change in acquisition following a ~1.5 year period of intervention and found a steep increase in adoption from 28 to 64% of owned dogs reported as adopted (Lee 2013). As discussed earlier in relation to dog population stability, estimating changes in immigration is important and hence when exploring acquisition whether the dog was sourced from locally or from outside the intervention area should be asked.

The **proportion of the dog population that was confined for all or part of the day** was explored in a number of studies. Interestingly, no literature reporting the impact of an intervention on confinement

could be found; this may be a goal for some stakeholders, although how this is done may be of concern, for example an increase in tethering would not be beneficial for individual dog welfare (despite reduced chances of road traffic accidents) and may have some bite related problems as tethered dogs are over-represented in the bite data. A commonly asked question was whether the dog was confined or not with answers categorised into always, partially or never (Hsu et al. 2003; Pulczer et al. 2013; Acosta-Jamett et al. 2010), in some cases a specific time of day was included to establish whether owned dogs were likely to have been roaming at the time of a street survey (WSPA 2007). Using questionnaires alone clearly relies on the owners ability to answer accurately and truthfully, there is some evidence that dog owners in Chile sometimes reply that their dogs are confined when clearly they are not, presumably because they believe that they are supposed to confine them (Elena Garda and Guillermo Pérez *pers comm*). One alternative approach was to record whether dogs were present at the time of the questionnaire; this was done by Kayali et al. 2003 in Chad and Gsell et al. 2012 in Tanzania, however Alena Gsell only report the level of confinement described through the questionnaire and not what was actually found when they visited the household, it would have been interesting to know whether the reports matched the availability of dogs (she offered vaccination of any dogs that had missed the previous mass vaccination event).

Learning point – When using questionnaires to ask about care provided to dogs consider asking a question that explores whether a behaviour has been performed or not. Avoid questions that ask the owner to make a judgement whether they provide care 'regularly' or 'often' and ask instead if a behaviour has been performed in a set-time frame – e.g. "did you feed your dog yesterday?".

Promising alternatives to questionnaires are participatory research methods (Chambers 2007). These approaches utilise groups of local people lead by a facilitator to discuss, measure and report on important data, usually benefiting from exercises that encourage engagement of all members of the group. There use with dogs has been reported once in the literature by Michelle Morters (Morters, Bharadwaj, et al. submitted) where she used a set of participatory exercises to explore the feeding owned dogs. Similar approaches have been used to explore and improve the care provided to working equines by Brooke (Dijk et al. 2010).

Learning point – Participatory research methods could provide alternative ways of measuring indicators relating to dogs; although relatively new to dog research this approach appears to have worked well for impact assessment of working equines interventions (and many human development interventions).

One novel indicator of the care provided to dogs was an **increase in the purchase of pet food** from local grocers in a Lakota Reservation, USA, undergoing an intervention that combined spay/neuter, adoption off site and basic health care provisioning intervention (Steinberger 2012). The number of the dogs on the reservation had declined and an improvement in body and skin condition had been reported by the clinics. The project manager wanted to determine if the improvement was due to the pro-active efforts of the owners or some passive effect of a reduction in dog density, so she called local grocers to explore changes in sales of commercial dog food; the finding was that sales had increased despite a reduction in the overall dog population size. An indicator such as purchase of pet this may be influenced by other factors such as a change in disposable income, so if data is available, changes in income could also be

compared across the same time scale to establish this is a contributing cause, as opposed to an assumed change in the desire to feed dogs a 'better' diet.

A final indicator of care or 'responsibility' of owners is to measure **owner engagement in the intervention** itself. Again in the Lakota reservation the proportion of dogs brought to the clinic versus caught and transported by the project staff increased over time, including dogs that were already spay/neutered that were brought back for vaccination and 'wellness exams'; a service that had not originally existed as part of the intervention but was introduced as these returns increased (Steinberger 2010). Related to this are indicators of **owners' willingness to pay for an intervention**, Lunney et al. 2012 measured this with a questionnaire where they asked owners if they would be willing to pay for vaccination, >96% said they would, and whether they would be willing to pay for spay/neuter, around half said they would. This was only used as an initial assessment in this study, but could be repeated over time to assess how the intervention is impacting the proportion of people that are willing to pay and, in addition, the price people are willing to pay for dog care. Lunney et al 2012 did not mention whether they had stated a price for vaccination or spay/neuter when asking these questions, which is presumably relevant especially if the intervention aims to reduce cost of these services. Dürr et al. 2008 used a questionnaire to ask owners how much they would be willing to pay for rabies vaccination in N'Djaména, Chad and plotted the expected probability based on what people said they would be willing to pay against the actual vaccination coverage achieved through 3 different vaccination campaigns charging different amounts. The results found discrepancy between reported willingness to pay and actual behaviour; with fewer people actually vaccinating their dogs when it was provided free than you would expect from their reported willingness to pay and more people vaccinating their dogs than you would expect at the highest cost of US $5.82–$9.69. This suggests that willingness to pay should be treated with caution as a predictor of actual behaviour, but it could still be useful as a measure of intention to invest in care for dogs as there was at least a correlation found in Chad between stated willingness and actual vaccination behaviour, even if this diverged at the extremes. Owners could be asked how they felt about investing in different aspects of the intervention, e.g. registration/identification vs spay/neuter vs vaccination; the differential value they put on these services would be interesting to measure over time and pay inform the level of subsidy for each toll. *Need to explore economic theory and interpretation more deeply before suggesting such indicators in the guidance*.

5.2.4 Reducing risks to public health

In many DPM interventions the intended beneficiaries are not only the dogs but also people. Dogs can present a zoonotic risk and also a bite risk (with or without disease transmission), hence measuring the impact of DPM on public health is relatively commonly reported in the literature.

5.2.4.1 Reduction in rabies risk

Measuring the impact of a rabies vaccination campaign can be done with three different indicators; **the number of dogs bites or post-exposure treatments (PET) provided**, **number of dog rabies cases** and the **number of human rabies cases**.

Dogs bites can be measured in a number of ways (see the later section on dog bite indicators) however for impact assessment of rabies control interventions the **number of animal bites treated by hospitals** has proven useful (Cleaveland et al. 2003; Reece et al. 2013); this is based on the assumption that if there are more symptomatic rabid dogs there will be more dog bites that people will want to have treated. Collecting data on dog bites may be relatively simple if these data are reportable to a central authority (usually a human health department) who then presents these data publically (e.g. as used by Reece 2012), however where this is not done managers may need to approach hospitals directly and ask for their cooperation in collecting and reporting bite data. One alternative method of measurement, used by Tenzin et al. 2012 to develop a cost-benefit analysis of rabies control in Bhutan, is to use the number of doses of human vaccine imported per year as a proxy of bite treatment, on the assumption that vaccine is not increasingly stockpiled. It should be noted that this indicator of treated bites is also influenced by people's propensity to report bites for treatment, hence if the intervention includes an education programme on bite treatment or improving the delivery of PET through health services the reported bites may increase. This was seen in Colombo, Sri Lanka where the number of dog rabies cases decreased over the 5 years of the intervention but the number of bites treated at the general hospital increased along with the reported understanding of the need for PET as measured through a questionnaire (Häsler et al. 2012). Hence it is ideal if more than one indicator is used, for example Cleaveland et al. 2003 used both dog bites reported by three district hospitals and dog rabies cases reported by livestock field officers. Further (Putra et al. 2013) utilised all three indicators in combination to evaluate the impact of a rabies vaccination campaign on Bali.

Measuring the indicator of **number of dog rabies cases** can also present challenges. Even in rabies endemic countries, rabies has a low incidence and so random sampling of animals would require huge numbers of animals to be killed (rabies diagnosis requires brain sampling and so cannot be done on a live animal) in order to confirm a single case; an ethically and practically implausible approach. So the advice is to only test high-risk animals, those that are biting, behaving strangely, morbid or found dead (Townsend et al. 2013). Rabies does present with very noticeable clinical signs and there is no carrier status (persistently healthy animals that shed virus; note infected dogs may shed virus in the days immediately preceding the onset of clinical signs) and so this focus on high-risk animals should be sufficient; municipal veterinary department records were used successfully to evaluate intervention impact in Colombo, Sri Lanka where this approach of diagnosing high risk cases was used (Sankey et al. 2012). However, detection rates for dog rabies cases are notoriously low and potentially could be leading to elimination failure as control measures are relaxed due to mistakenly believing rabies has been effectively controlled; Townsend et al. 2013 concluded that at least 5% but ideally 10% of cases need to be detected to have realistic prospects of eliminating rabies. Methods of measurement that have shown success in detecting dog rabies cases (and dog bites) include volunteer and community based 'rabies workers' (e.g. Kitala et al. 2000; 'rabies watchers' on Bohol); rabies projects run by school-boys (Kitala et al. 2000) and incentives provided to livestock field officers (Cleaveland et al. 2003). Townsend et al. 2013 further advise the use of inter-sectorial collaboration where medics report bites or suspect human rabies to veterinary authorities for prompt follow-up and vice versa in the case of dog rabies cases, plus the use of rapid diagnostic field detection kits to avoid the barriers of transporting carcasses and expensive laboratory facilities.

The **number of human rabies deaths** should be relatively easy to measure in countries where rabies is a reportable disease as these data should be available from a central government repository. For example Chomel et al. 1988 utilised rabies case data from the Peruvian Ministry of Health to evaluate the impact of a mass vaccination campaign in Lima, Peru. Hopefully these data will be publically available, although it may need to be specifically requested by managers or even sought through a freedom of information

act. However where rabies is not reportable or under-recognized, managers may again need to build collaborative partnership with hospitals and local health care service providers to access these data (e.g. as done by Sunil Chawla in Reece & Chawla 2006). (*I am conscious that there is more to this story about human rabies cases and will be following up on this further, in particular with the team at Glasgow*).

One factor common to both human and dog rabies case data is the issue of whether these are laboratory confirmed cases or only clinically diagnosed. The World Health Organisation state that effective rabies surveillance should be based on laboratory confirmed cases, however laboratory facilities are by no means ubiquitous and so efforts to conduct surveillance of rabies based on clinical diagnosis alone should not be ignored. The important point to keep in mind when conducting impact assessment is not to change part way from clinical diagnosis to laboratory confirmed without some effort to reconcile the difference this change of method will have on the indicator of dog/human rabies cases; although laboratory confirmation is ideal, the additional process of removing brain samples, transporting them to the laboratory and completing the test means that the number of cases tested and confirmed is likely to decrease simply due to logistics.

Learning point – Measuring the impact of an intervention on rabies risk is ideally achieved via measuring a combination of three indicators; dog bites, dog rabies cases and human rabies cases (plus vaccination coverage to establish attribution of the impact). With rabies cases confirmed through laboratory tests and 10% dog rabies case detection. However, this will not be possible in all locations and hence this should been seen as an ideal and any attempts at monitoring encouraged (do not let the perfect be the enemy of the good!).

In the introduction to this literature review I stated the assumption that we are more interested in indicators of impact than effort. However, in the case of rabies interventions it seems valid to include a short discussion of **vaccination coverage** as a measure of intervention effort as this is very commonly described along with indicators of impact to justify attribution of reduced rabies risk to the intervention. Vaccination coverage has been measured in three main ways; number of vaccines delivered as a proportion of estimated total dog population, questionnaires asking owners to state whether their dog is vaccinated and mark-resight methods when dogs are marked with an ear-notch, collar or paint spray at the time of vaccination. Using number of vaccines delivered as a proportion of total dog population is plagued by the difficulty in accurately estimating dog population size and has led to inaccurate estimations of coverage (Sarah Cleaveland *pers comm*). Questionnaires conducted in a sample of areas asking owners whether their dog was vaccinated is most widely used and seems suitable in countries were dog populations are majority owned. Many use a system of cluster sampling (specifically citing the WHO Expanded Programme on Immunization cluster-survey technique) to access a random sample of households (Davlin et al. 2013; Kongkaew et al. 2004). In some cases verification with either a certificate or collar/tag was required before the dog was considered vaccinated (Kongkaew et al. 2004; Touihri et al. 2011) whilst others were content with owner reported vaccination (Davlin et al. 2013). Some studies used both questionnaires and observing the proportion of marked roaming dogs to measure vaccination coverage; Cleaveland et al. 2003 found relatively similar results with 62.1% coverage estimated through mark-resight on transects and 67.8% estimated from questionnaires in Tanzania. Mark-resight methods risk underestimating coverage due to mark loss, although Chomel et al. 1988 found only 2% loss after 1 month, plus confined dogs will not be observed during street resight surveys and Davlin et al. 2013 found greater odds of vaccination in confined owned dogs, plus if there are alternative services for vaccination such as private veterinarians who will not be marking dogs in the same way as a mass

vaccination intervention. Conversely questionnaire methods only measure owned dog vaccination coverage and where unowned dogs exist as a significant proportion of the population this would overestimate coverage. The appropriate method of measurement clearly depends on the ownership status of the dog population and therefore the intervention focus; where the intervention focuses on unowned dogs the coverage is best estimated with mark-resight, such as in India with ear-notches applied to vaccinated and sterilised dogs (Reece & Chawla 2006). Where owned dogs are commonly confined, questionnaires would seem the best approach, especially where a proportion of the dogs may have been vaccinated through other services. Where dogs are majority owned but allowed to roam a combination may be best, with the resource-efficient mark-resight approach used in the majority of samples and then in a smaller sample, perhaps in particular those below the target coverage assuming mark-resight is an underestimate, a more intensive questionnaire effort is used to validate the coverage estimate.

Learning point – Appropriate method of measuring vaccination coverage (an indicator of effort not impact) will depend on ownership status of dogs and whether vaccination is likely to have been done through services other than a campaign that marked dogs at the time of vaccination (e.g. private veterinarians). Where dogs are majority owned but also usually free-roaming, a combination of (majority) 'resource-light' street surveys recording proportion marked and (minority) 'resource-heavy' questionnaires, where street surveys report below but close to target, may be most efficient. We need to establish key questions (probably focused on mark loss, vaccination of confined dogs and vaccination through other services) in order maximise questionnaire data as a means of validating estimates of vaccination coverage from street surveys of marked dogs. Need to consider how to establish the breakdown of the population into owned/unowned first in order to select the correct method of measurement.

Seroprevelance/blood testing for rabies is not considered beneficial for monitoring rabies incidence. Because the disease is fatal in such a short time span, antibodies in blood samples reflect vaccination history only (an exception of this was found in Tanzania with 5-10% of dogs showing positive rabies antibodies with no vaccination history and no subsequent disease, suggesting "aborted infection" with the immune response resulting in clearance of virus Cleaveland et al. 2007). In addition, because immunity to rabies involves mechanisms other than circulating antibodies, a titre below the perceived 'protective' level does not necessarily mean the dog is not immune. For these reasons, and perhaps also with the costs of antibody testing in mind, WHO advise "measurement of rabies-specific antibodies is not recommended for routine rabies surveillance" (pp 93, WHO 2013).

5.2.4.2 Reduction in risk of other zoonoses

Leishmania and eccinochocus – *very little found – still working on this, will need to contact experts in the field because so little found on impact assessment of these diseases, but I do think they are relevant to include.*

5.2.4.3 Reduction in dog bites

The indicator of **number of dog bites** is a perfect example of where the method used to measure the indicator should be clearly stated and changes in incidence must be assessed using the same measure. As described by Andrew Rowan (Rowan 2012), dog bites can be measured through different methods; questionnaires asking people if there have ever been bitten; officially reported dog bites (whether dogs bites are reportable will vary with country, presumably it is more common in rabies endemic countries); emergency room visits (*are these not also reported bites? Are these reported differently to those requiring less intensive treatment? Need to explore further how these differ from the previous category*); and bites that require surgical reconstruction.

Timeframes used to explore bite incidence can also differ, in particular with questionnaires, with some asking people if they have ever been bitten within their entire lifetime (Pérez & Garde 2012; Farnworth et al. 2012), some asking about bites within the last 5 years (Lunney et al. 2012), some in the last 2 years (Lunney et al. 2011) and some in the last year (WSPA 2007). For reasons of reliable recall by respondents, and for establishing an impact assessment within the shortest frame (number of bites in your lifetime may not reveal a change in bite rate for a generation), a short timespan within which a bite has occurred seems sensible.

Learning point – Shorter timeframes for exploring number of dog bites seems ideal for revealing impact as soon as possible, e.g. when using a questionnaire as a method of measurement post the question "have you been bitten in the last year?" This may also avoid issues with poor recall over longer time-frames.

It may also be useful to consider how the incidence of dog bites is presented in relation to other influencing factors, for example human population size. As the human population within the hospital catchment area grows, so the number of bites treated is likely to rise, not due to an increase in biting behaviour of dogs but due to more people, and therefore more dogs, ending up in situations where bites can occur. Reporting bites per unit of human population is relatively common, usually 10,000 (e.g. Thompson 1997) or 100,000 people (e.g. Ozanne-Smith et al. 2001). This allows for comparisons of bite incidence rate to be compared across different locations, so long as the methods used to collect the number of dog bites are also the same. This may also be particularly important in countries with fast growing urban populations where hospital catchments will rise steeply over the intervention period targeted for impact assessment.

It may also be useful to include a measure of dog density, for example number of roaming dogs per km of street surveyed, to establish how the bite incidence is changing not just accounting for changes in human population but also in terms of dog population; although no literature could be found that had utilised this additional relational factor (*this needs more thought, in particular whether a decline in bites per 100,000 people per dog density measure could be caused by something other than each dog presenting a lower bite risk?*).

Learning point – Reporting bite incidence per 100,000 people appears sensible for the developing world where urban growth is particularly large and so human populations within hospital catchments may increase rapidly – ideally an estimate of hospital catchment would be needed for every year of bite data.

A final point about dog bite data is that plotting data across smaller timeframes may be useful, for example monthly dog bite incidence. This may expose patterns in bite incidence that reveals potential underlying causes of bites. This comes primarily from Reece et al. (2013) where monthly dog bite incidence in Jaipur, India revealed a peak around 10 weeks after the peak whelping date of street dogs when they assumed puppies would become most visible and attractive to people, especially children, to try and pick-up. Further they found a significant decline in bite incidence over the period of their intervention, which included spaying the vast majority of female roaming dogs, hence they attributed at least part of this bite decline to a reduction in maternal aggression.

5.2.5 Improve public perception/satisfaction

An impact of improving public perception/satisfaction in relation to street dog populations may be particularly attractive to those stakeholders with political concerns; but is arguably also beneficial from the perspective of dog welfare on the assumption that a more accepting public may treat street dogs with greater tolerance.

Attitude statements were commonly used with either yes/no/don't know options or Likert scales (5 or 7 levels of agreement from strongly disagree to strongly agree) on which dog-owners or non-owners could state their level of agreement (*need to explore further the pros/cons of yes/no versus Likert scales – compare sensitivity to change and ease of analysis and interpretation*). Four studies were found that assessed people's attitudes to problems related to dogs (Lunney et al. 2012; Lunney et al. 2011; Pérez & Garde 2012; Farnworth et al. 2012) however only one study had attempted to measure the change in attitude in response to an intervention; this study used the same questionnaire 5 years apart on a cross-section of people each time (Häsler et al. 2012). One challenge with attitude statements is to ensure that the statements themselves, or the interviewer, do not lead people to respond in a certain way. Lunney et al. 2011 appeared to include only negative attitude statements in their questionnaire (although they may be preferentially reporting negative statement results and the questionnaire itself may have been more balanced) and in 2012 (Lunney et al. 2012) seemed to ask just one question about whether "…ownerless dogs from the street caused them problems", which would arguably not expose any empathetic feelings towards the dogs that you may want to identify in an impact assessment. In comparison, following pilot testing a large number of statements a mix of 18 both negative and positively phrased statements were included in questionnaire used in Colombo, Sri Lanka (WSPA 2007).

In most studies, responses to each attitude statement were presented as % of respondents that agreed or disagreed, each attitude statement hence providing a potential indicator of public perception. However Häsler et al. 2012 also reported a summative score comprised of the responses to 11 attitude statements, both positively (e.g. "I like having dogs on my street") and negatively ("street dogs pose a danger to people") termed. The combination of these questions was perceived to be measuring tolerance or acceptance of dogs; this was called the '**summative acceptance score**' and was used as an indicator of change in public perception over time.

One interesting set of attitudes and experiences, explored through four different questions in a questionnaire delivered by Farnworth et al. 2012 in Samoa, related to **people harming or killing dogs**; disturbingly a 1/3 of people had experienced this, and gave several reasons why this had occurred, mostly commonly that the dog was too aggressive or sick. However because three of these questions asked for their experience of this behaviour over the respondent's lifetime, even a sudden cessation of this behaviour would not be revealed through repeat measurement of this indicator until another

generation had passed. However, the fourth question asked for the respondent's opinion of whether this "…harming or killing of dogs was good for Samoan society", which if repeated would potentially reflect a change in attitude as it happened. Farnworth et al. 2012 also explored some of the beliefs/reasoning the attitude statement "**do you think dogs are a nuisance?**"; 3rd on the list was 'when dogs were sick' and 6th was 'when they are on heat'. These additional details relating to perceived nuisance could increase sensitivity in measuring change, although a test of this was not found in the literature.

Learning point – Asking questionnaire respondents for their level of agreement with attitude statements can reveal their perceptions of dogs. Providing a balance of both positive and negative statements may help to avoid biasing responses; order of presentation will also be critical. Further open questions about key attitude statements may increase the sensitivity of the indicator to change; although no test of this could be found in the dog literature.

There are some human behaviours that could be used as indicators of public perception of roaming dogs. Toukhsati et al. 2012 used a telephone survey in Thailand to explore the **prevalence of feeding ownerless dogs and cats**. Although they only conducted this survey once and did not use this to evaluate the impact of an intervention, it is assumed that an increase in tolerance/acceptance of roaming dogs would be reflected in providing greater care to them such as feeding. In Colombo, Sri Lanka, sterilised and vaccinated dogs that were living in 'dog managed zones' were seen to increase in body condition with some becoming quite obese, this was reported to be due to increased purposeful feeding by people that worked in this zone as a result of these dogs being perceived as 'safe' (Nalinika Obeyesekere, *pers comm*). However any change in feeding of ownerless dogs can cats over time may be difficult to interpret, both because of the over-riding impacts of religious/cultural beliefs and also how would one expect this behaviour to change over time? Less ownerless dogs would need less food but would this equate to less people feeding or each person feeding a smaller quantity? Would an increase in feeding by an indicator of increased tolerance towards dogs? Or would people who feed ownerless dogs potentially adopt them as their tolerance increased further and so feed the same dog as their owned dog? Because interpreting change in this behaviour would be difficult it may be best to reply on other more straightforward ways of measuring tolerance.

Another behaviour potentially reflecting public acceptance of street dogs is **adoption of dogs direct from the street**; this is described in more detail in the section on improving care provided to dogs, but could also be used as an indicator of public acceptance of street dogs. Finally the **proportion of positive/negative interactions between people and street dogs** could also reflect public tolerance; this was also suggested as a potential indicator of dog welfare in an earlier section and although it has received relatively little attention to date this may be a fruitful indicator to explore further, not least because it could reflect changes in several related impacts.

Learning point – Some human behaviour indicators mentioned previously in relation to other impacts may also be useful for reflecting a change in public perceptions (e.g. adoption of street dogs and positive/negative interactions between street dogs and members of the public).

Most of the studies described in this section utilised questionnaires to explore perceptions, however participatory research methods may again prove to be more efficient and revealing methods of measurement. One study was found that had used participatory methods to explore people's perception of the **number and type of problems caused by dogs** (Häsler et al. 2012). Furthermore they had specifically asked people to recall how the situation had differed from 5 years previously in order to evaluate the impact of an intervention. This approach appeared to be successful, with fewer problems relating to dogs being reported in the present as compared to 5 years previously. Unfortunately, this approach had not been used before the intervention so it was not possible to validate the accuracy of the recall. However, even if recall was not perfect this method revealed that people *perceived* the situation to have improved significantly in relation to dogs which was very useful and rewarding for the intervention managers.

Learning point (repeated from earlier section) – Participatory research methods could provide alternative ways of measuring indicators relating to dogs; although relatively new to dog research this approach appears to have worked well for impact assessment of working equines interventions (and many human development interventions)

Whether dogs are culled or not could perhaps be used as indicator of public or government tolerance of dogs. Although it should be noted that governments may act against majority public wishes in response to a vocal minority. No literature could be found that reported the cessation of culling in response to an intervention, but interventions may have been initially introduced on the agreement that culling was not used. Methods used to collect information on dog culling would primarily be accessing information from governments (central and municipal).

5.2.6 Improve rehoming/adoption centre performance

Indicators related to rehoming/adoption centre performance could be argued to be a measure of centre effectiveness and therefore related to intervention effort and not impact (mentioned as a key assumption of the literature review). However, many parts of an intervention have the potential to feed into whether a centre is successful or not, sometimes independently of the actions of the centre itself. For example spay/neuter could reduce unwanted births which would reduce intake and an improvement in people's perceptions of dog could increase adoptions. Hence a discussion of indicators relating to this impact is included here.

The USA based Asilomer Accords (Anon 2004) is perhaps the most famous initiative to create a reliable and shared indicator of centre performance; **the annual live release rate**. The annual live release rate is expressed as the percentage of total outcomes for shelter animals that are live outcomes (adoptions, outgoing transfers, and return to owner/guardian); the total outcomes include all live outcomes plus euthanasia not including owner/guardian requested euthanasia or died/lost in shelter/care. The guidance provided by the Accords includes a heartfelt set of principles that appear to have performed well at maintaining collaboration and consistency in the animal welfare movement in reporting their annual live release rate. This was also successful because the guidance provides not just very clear definitions of the data to be used in the calculations of these rates, but also practical tools such as a data gathering form and simple equation for the calculation of the rate itself. Annual live release rates have

hence been used to evaluate impact of interventions on both individual centres and whole communities comprised of several centres (e.g. Weiss et al. 2013).

However for centres that have a 'non-destruction' policy their annual live release rate will always be 100% and hence they require additional indicators, these will also be useful for centres without 100% live release rate to explore their performance in more detail. **Intake rates**, split by age category are an indicator of the size of the unwanted dog population and have been used in evaluation of intervention impact (e.g. Frank & Carlisle-Frank 2007). **Net rehoming rates** include both the number of dogs rehomed and takes account of any returns across a specified time period. **Footfall** across a specified time period is the number of visitor groups (families and couples count as one) to the centre. Changes in **ratio of net rehoming: footfall** allows for a quick evaluation of the success of rehoming dogs as it takes into account the number of opportunities dogs had to be adopted. **Average time spent in the shelter** can be an indicator of how long it takes for a dog to be rehomed, the proportion of dogs over a certain length of stay (e.g. 6 months) may also be an important indicator of shelter performance as these long-term dogs will presumably be suffering some welfare compromise.

Learning point – Annual live release rate is a well-accepted indicator of centre, and community comprised of several centres, rehoming/adoption performance. Additional indicators of intake rate, net rehoming rate (incorporates returns) and footfall (plus a ratio of net rehoming:footfall), and time spent in the centre may well be useful for measuring centre performance in more detail, in particular for centres where their policy of non-destruction will lead to a stable 100% live release rate.

5.2.7 Reduce negative impact of dogs on wildlife

The impact of dogs on wildlife can occur in several ways; Hughes & Macdonald 2013 reviewed 69 papers on interactions between dogs and wildlife and found the main interaction was predation of wildlife by dogs, followed by disease transmission to wildlife, then relatively limited reporting of competition with wild carnivores, hybridization and predation of dogs by wild carnivores. In this section the focus is on indicators reflecting the first two interactions of predation and disease transmission, it should be noted that in all cases collaboration with wildlife stakeholders would be advised in order to collect data relating to wildlife populations.

One generalised indicator of potential dog wildlife interaction is the **presence of dogs within designated wildlife areas**. Butler 2004 had rangers record sightings of dogs and dog prints along a transect within the border of the wildlife park, about 6 times per month, providing a long term and relatively detailed relative index of dog abundance in the wildlife area. Wildlife designated areas may also have ongoing population surveys of wildlife that can include dogs as one of their identified species sightings, hence providing an indicator of relative abundance of dogs within these designated areas. For example Manor & Saltz 2004 in Israel recorded any dog sightings whilst surveying for mountain gazelle at water holes, they used the proportion of observations in which dogs were sighted as a 'dog-presence index'.
One more resource heavy approach is to radio/GPS collar a sample of dogs in order to measure the overlap between dog ranges and wildlife designated areas. Further, dogs can be followed using these collars as they enter the wildlife areas to increase the chance of seeing them interact with wildlife (e.g. Butler 2004).

5.2.7.1 *Reducing predation of wildlife by dogs*

Predation of wildlife by dogs may be difficult to monitor via direct observation during transects or point surveys as predation is rarely seen. However, as with rabies, which is a similarly rare event, community based volunteers and wildlife rangers can be asked to report the **number of observed wildlife kills by dogs** to a central organisation (Butler et al. 2004). As mentioned in the previous section, a relatively resource intense approach is to radio/GOS collar a sample of dogs and follow them as they enter the wildlife area to increase the chance of observing a predation event. Conversely, a sample of the wildlife species can also be GPS collared with mortality sensors to allow for prompt necropsies and identification of the predator involved using scat, tracks and distance between puncture wounds, although differentiating between wild canids and domestic dogs is not possible with these signs alone (Young et al. 2011). If the predation event is not observed mitochondrial DNA analysis can be conducted on the saliva left on the carcass in order to establish the species responsible (Williams & Johnston 2004). In fact, this approach can even be used to identify the individual responsible if salvia samples can also be taken from 'suspects'. However this must be done within a short time period of the kill to avoid contamination of the predator's saliva with scavenger salvia, in some environments this may well be a matter of just a few hours, plus the tests themselves are likely to be quite expensive.

Utilising the indicator of the number of observed wildlife kills by dogs alone is not really sufficient as reported in Hughes & Macdonald 2013; this is "unquantified in terms of population impacts. Reporting individual instances of predation gives no indication of the impact on local prey populations and, therefore, whether it is of conservation concern". Hence additional indicators needs to be used to reflect how the wildlife population is responding to this predation. Ideally by **monitoring population numbers and structure of wildlife prey** at the same time as monitoring presence of dogs within designated wildlife areas or number of observed wildlife kills by dogs to see if there is any correlation. For example, the dog-presence index used by Manor & Saltz 2004 was found to correlate with kid:female gazelle ratios; with a more kids per female, a favourable ratio in terms of the potential for gazelle populations to grow, as dog-presence index declined.

Learning point – The number of predation events by dogs alone is not sufficient to assess the true impact of dogs and whether this is changing over time. The impact on the wildlife population size and structure should be measured along with the presence of dogs in wildlife areas/number of kills observed.

5.2.7.2 *Reducing disease transmission to wildlife from dogs*

Rabies and canine distemper viruses are considered major pathogens affecting wildlife, particularly carnivore populations (Woodroffe et al. 2004). For both viruses, dogs may act as reservoir hosts – they maintain and transmit infections of rabies and CDV to wild and other domestic populations of animals (Cleaveland et al. 2007). The short infection cycle and high mortality rate, a common characteristic of both viruses, means that transmission cannot be maintained in small endangered wild populations; as the number of animals that succumb to infection increases, the number of new susceptible hosts diminishes, and the infection eventually fades. New infections in wildlife populations are invariably

triggered by contact with the more abundant reservoir hosts, most often these are dogs (Cleaveland et al. 2007). Measuring the success of interventions to manage both diseases, inevitably requires surveillance of both dog and wildlife cases. Therefore, providing an **incidence rate of rabies/CDV in both dogs and susceptible wildlife species** within the same area may be a useful indicator of success of disease intervention programmes, adjunct to dog population management. Further, detailed analysis of the relationships between incidences in the two populations is recommended (Woodroffe 1999) to understand the mechanism of transmission between wildlife and dogs as reservoir hosts (Cleaveland et al. 2007), and inform future disease management plans.

This approach will inevitably require collaboration between different stakeholder groups focused on both dogs and wildlife. A good example of this approach, was intervention trials involving mass vaccination of dogs against rabies and CDV in the Serengeti, to reduce the incidence of these diseases in wild carnivores (see Cleaveland et al. 2007 for a review). Central to intervention, was the need to develop a monitoring system for diseases in wildlife and dog populations. The resulting disease surveillance network included areas within and surrounding the Serengeti National Park – the areas where dogs and wildlife meet, and necessitated greater integration between research and park management, and collaboration between veterinary officers involved in managing livestock and wildlife health. Such recognition of the need for disease surveillance in wildlife has led to the routine use of a small carnivore disease monitoring programme (using distance sampling techniques) as part of the Serengeti National Park management activities (see Cleaveland et al. 2007).

Learning point – Surveillance of disease in both dogs and wildlife species will be needed to assess the impact of disease interventions; this may require initiatives to increase surveillance efforts and integration between dog and wildlife stakeholders.

The **proportion of the dog/wildlife population with CDV antibodies** may be a useful indicator to measure through blood testing. However CDV antibodies can remain in circulation many years after exposure to CDV and so a single blood sample is not a good measure of recent disease incidence. CDV antibody seroprevalence could be used for impact assessment if conducted in the long-term and across a range of age groups. For example, when used in the Serengeti this approach revealed that CDV appeared and then disappeared for many years in hyenas before reappearing in juveniles, suggesting that the virus was not persisting in this wildlife species and had been introduced by dogs acting as a reservoir host (Cleaveland et al. 2007). Where CDV vaccination of dogs is planned as part of a DPM intervention the seroprevalence for CDV antibodies in dogs would only be useful as a baseline as the vaccination itself would result in a positive blood result. After the vaccination has commenced the incidence in wildlife would need to be measured instead along with a continued surveillance of active CDV disease in dogs through clinical diagnosis of sick dogs and necropsies. There are tests using PCR that can distinguish between vaccinated dogs and naturally-exposed dogs, but these would be too expensive for routine monitoring.

Learning point – Blood sampling for antibodies to canine distemper virus will only be useful if conducted over the long-term and across age groups to understand disease epidemiology. If an intervention includes vaccination it should be noted that vaccination itself will also produce a positive blood result for antibodies.

5.2.8 Reduce negative impact of dogs on livestock

Very little literature could be found on measuring the impact of dogs on livestock. Adriani & Bonanni 2012 reports using data from Merops Veterinaria e Ambiente s.r.l. (MVA), the insurance company that farmers access compensation from, for a the **number of livestock predation events by dogs** in Italy. Farmers also had to report livestock predation to the local authorities so that attempts could be made to trace the dog owner. However it appears that the data from the insurance company was more accessible/useful than from the local authorities. Presumably in some countries there is centralised reporting of predation by dogs, in particular where there is government compensation for losses. In the UK, authorities have not kept a record of predation of livestock by dogs since 1978 (RSPCA 2010) and hence again insurance companies may be a better source of data. Where this secondary data source does not exist, questionnaires of farmers may be a potential alternative, for example Wang & Macdonald 2006 asked farmers living around a wildlife park in Bhutan about predation events, although in this case they didn't report losses to dogs, only wildlife predators. The challenge when looking into dog predation is that farmers potentially suffering from these losses will be spread across the country as opposed to focused around a park as in wildlife predation. In this case focused recruitment through farmers networks may be a better method of finding respondents.

I am conscious that there will potentially be more to add to this section when I have been able to follow-up further on Echinococcus.

5.3 Summary of methods of measurement used with dog populations

In the above review of indicators used to reflect changes in DPM-related impacts, several methods of measuring indicators were revealed. In this section these methods are briefly summarised and critiqued in terms of their application to communities searching for cost-effective impact assessment.

Cohort studies, longitudinal studies which follow the dog population living in a specific group of households, produce very detailed life histories of dogs and so produce data related to dog demography. Key findings from cohort studies include that a surprisingly large proportion of dogs are brought into populations by dog owners as opposed to being born locally (Morters et al. submitted), that even in the absence of intervention dog populations can be stable or even decrease in size (Morters et al. submitted) and that mortality rate can exceed birth rate and immigration is used by dog owners to maintain populations (Darryn Knobel *pers comm*); factors that needs to be kept in mind when using reproduction control that reduces birth of dogs locally as this may increase immigration. Such findings would be difficult to replicate without the use of cohort studies. In human development and health Human Demographic Surveillance Systems (HDSS) are used to follow the demographic process of all people living in surveillance area, using repeated face-to-face interviews. This approach provides unique understanding of trends in human health and social development and is used to feedback on development intervention effectiveness and to advise on policy (Sankoh & Byass 2012). However, these studies involve repeated visits to large numbers of households for interviews and, in the case of dog-related studies, clinical examination of dogs over many years, something that will be beyond most DPM interventions. One option is to suggest small scale cohort studies, too small for statistical significance but could allude to many of these processes that would otherwise be invisible. For example, selecting 20

households that fall into 4 categories of ownership: non-owners, owners that confine their dogs; owners that allow their dogs to roam; community dog owners (Becky Whay *pers comm*). Another potential route would be to 'piggy-back' on humanitarian focused cohort studies as they are likely to include large sample size providing higher quality data and an opportunity to highlight the link between companion animal and human health.

Learning point – Cohort studies are very intensive but provide almost unique information about dog demography. Perhaps small scale cohorts could be followed to expose some of the otherwise invisible processes; alternatively including dog related questions in human focused cohort studies.

Questionnaires were the most frequently reported method used, usually via face-to-face interview on the door-step but also over the telephone; this approach is most suited to assessing the own dog population size, care and people's attitudes towards dogs. Telephone surveys are apparently increasingly less reliable ways to access a representative sample of the general public because landline penetration is reducing as mobile phones become more widely used by younger generations, in particular those that move house regularly. Interestingly no literature could be found that used social media to attract respondents to engage in online surveys which may prove a more cost-effective approach if the biased sampling challenges can be overcome (*please note, I am following up on the method used by YouGov in the PDSA & YouGov 2012 which apparently did use an online survey method*). Questionnaires can provide good data on owned dog populations and owner behaviours and attitudes. A way of improving questionnaire data became apparent in the review; ask people about dogs that have left their house in the previous year or litters born in the previous 1-3 years to estimate birth and death rates; ask people about acquisition of their dog including whether they were from within or outside the study area to expose rates of immigration; when asking about owner behaviour or dog-related experiences like bites ask within a specific short timeframe, preferably last 12 months to avoid problems with poor recall and also to allow for measurement of change across reasonable time periods (i.e. questions about bites in your lifetime will take a generation to show any change even if bite reduce almost immediately). One challenge with questionnaires is the time they take to implement and also to analyse, this may explain why very little literature could be found that used questionnaires in actual evaluation of impact. If we are to advise the use of questionnaires in future it would seem advisable to provide key questions that make the data useful for evaluation along with tools to improve data gathering and analysis; such as tablet apps that can be used during the interview with respondents and can further store and analyse the data.

Learning point – Questionnaires are commonly used for initial assessment of dog populations and their owners but not for evaluation as they are time consuming to implement and analyse. There are some questions and phrasings that lend themselves to evaluation. Providing project implementers and evaluators with advice on these questions and tools to reduce resources required to complete them seems useful for the project.

Street dog surveys were perhaps the most common methods used in evaluation of DPM in resource limited communities where roaming dogs are common; these surveys produce data related to dog density and health. These are relatively fast to implement and can measure the welfare and density of the roaming portion of the dog population which is arguably the most relevant for DPM impact (even if

the interventions themselves are delivered via owners). Hence when repeated consistently over time street dog surveys can provide a measure of change in welfare and density. There are various techniques that can be applied during street surveys; including mark-resight, direct observation along set routes or blocks and point counts. Dependent on the techniques used the resulting data are either an estimate of absolute population size or an indicator of relative abundance/density. Establishing an absolute population size requires significantly more survey effort and often the analysis falls foul of assumptions that are not met by roaming dog populations and so in reality is an indicator of relative abundance and not an accurate estimate of absolute size. With this in mind, encouraging the most resource efficient survey approaches that transparently produce indicators of relative density may be advisable. One additional potential improvement to street surveys would be the inclusion of behavioural indicators, which are relatively widely used in farm animal welfare assessment but have received very little attention in dog studies so far.

Secondary sources of information or official records were used by a number of studies of impact; e.g. dog bites, dog rabies cases, human rabies cases, live release rates from rehoming centres. Apart from effort required to access this information the DPM managers themselves do not need to invest any effort in this method of measurement and so it is ideal for resource limited communities. The challenges will be in the quality of this information. Arguably if data collection has been done through consistent (poor) effort, even if the data is not a true reflection of the absolute number of bites or deaths it will still provide a relative measure. Hence secondary sources that are known to have problems in data collection are still useful, but the quality of the data collection and initiatives to improve it should be monitored by the DPM managers to ensure they do not mistakenly attribute changes to the intervention that are actually due to changes in data collection. An additional challenge with official records is in the transfer of data from local authorities to central authorities; for example the reporting of bite incidence from local health centres to the Health Ministry. If this collation of data centrally through formal routes is challenged DPM managers may need to access this official data from the local centres as opposed to relying on state/federal sources.

Participatory research methods based on the original 'participatory rural appraisal' approachs have been used for decades to measure indicators of impact in human development and most recently in measuring impact in working equine interventions. These methods have received only very limited attention in dog studies and so far only one example of using them in evaluation could be found (Sankey et al. 2012). Despite this relatively limited testing to date this appears a fruitful avenue to explore further as this method can be very resource efficient. This method is presumably best suited to collecting data related to people's perceptions and behaviour towards dogs.

5.4 Impact assessment in other fields

The use of indicators and methods of measurement in other species, including humans, has been mentioned several times throughout this review on dog literature (e.g. behavioural indicators in farm animal welfare and participatory research methods in working equines and human development). In this section, impact assessment in non-DPM fields using a range of indictors are discussed as a source of inspiration for the guidance document.

In human development, there are several examples of what can be termed composite indices. For example, the human development index (HDI) is an aggregate of sub-indices measuring life expectancy, education and income. Economist Intelligence Unit's Quality of Life index used nine indicators of quality

of life, interestingly these indicators and their weightings were derived from life satisfaction surveys of members of the public in different countries. They found over 80% of the variation in life satisfaction scores could be explained by nine factors - the most important were health, material well-being, and political stability and security. Each factor has just one indicator all using official sources of information. Both the HDI and the Economist Intelligence Unit's Quality of Life index have a scoring system that reduces the data to a single number/score for each country. Reducing indicators down to a single score is attractive when the aim is to provide a comparison and benchmark between countries, but this does reduce the information available, for example a single score does not tell you the relative achievements against each indicator and where progress has been made or lost.

In farm animal welfare, the EU's Welfare Quality project is a good example of an index comprised of several indicators. Each farm animal species has a separate protocol with a range of indicators plus detailed explanation of the method of measurement failing into 12 criteria relevant for welfare (Jones & Manteca 2009). The indicators used are mostly animal based, and include disease symptoms, injuries and behaviours both between the animals and towards people. Each indicator is given a score and these are combined to provide a score for each of the 12 criteria, which is combined into a score for each of 4 principles of animal welfare and further into an overall welfare state for the farm (4 categories are possible). This reduction of scoring to a single state again has attractions for the EU who may want to compare farms on a macro level, however a single score does not help the farmer identify where he needs to improve. It may have been more beneficial to stop at combining indicator scores at the 12 criterion level as this would have reduced the data to a manageable level but also retained some meaning. The identified 4 welfare principles and 12 criteria within those are:

Good feeding

1. Animals should not suffer from prolonged hunger, i.e. they should have a suitable and appropriate diet.
2. Animals should not suffer from prolonged thirst, i.e. they should have a sufficient and accessible water supply.

Good housing

3. Animals should have comfort when they are resting.
4. Animals should have thermal comfort, i.e. they should neither be too hot nor too cold.
5. Animals should have enough space to be able to move around freely.

Good health

6. Animals should be free of injuries, e.g. skin damage and locomotory disorders.
7. Animals should be free from disease, i.e. animal unit managers should maintain high standards of hygiene and care.
8. Animals should not suffer pain induced by inappropriate management, handling, slaughter, or surgical procedures (e.g. castration, dehorning).

Appropriate behaviour

9. Animals should be able to express normal, non-harmful, social behaviours (e.g. grooming).
10. Animals should be able to express other normal behaviours, i.e. it should be possible to express species-specific natural behaviours such as foraging.
11. Animals should be handled well in all situations, i.e. handlers should promote good human-animal relationships.
12. Negative emotions such as fear, distress, frustration or apathy should be avoided whereas positive emotions maximised

The RSPCA conduct an annual assessment of animal welfare in the UK every year utilising 30 indicators relating to different species and several methods of measurement (journal and literature reviews,

Freedom of Information Act 2000, opinion polls, UK government and European Union statistics, online research, questionnaires and parliamentary questions) (RSPCA 2009). These indicators are not combined into a single score but for each indicator the data is compared to the previous year and a traffic light system is used to highlight whether the welfare problem has worsened, stayed the same, improved or there is not enough data to report the change. DPM-related indicators within this system include **the intake of stray dogs by local authorities and intake of unwanted dogs by the RSPCA** and their fate including the **number of dogs reported to be returned, rehomed and euthanased** which could been combined to create a single live release rate figure as mentioned earlier in this review.

Learning point – Reducing data from the indicators into a single score for each DPM intervention may be a step too far. However reducing data collected on indicator to a single score for each impact may help in presenting a large amount of data in a digestible form but will retain the different meanings of the impacts (e.g. a score for dog welfare, a score for public health and a score for public perception). Subsequently change could be presented in terms of % change for an impact score or just a traffic light system for positive, negative or no change.

6 Conclusions

This review opens with a list of 26 learning points that were drawn from literature review. These are not repeated here but should be considered an important part of the review conclusions and will feed directly into the next stage of structuring the guidelines.

The following sections summarise the indicators identified and an initial judgement on their suitability for DPM evaluation, a summary statement about the next steps for methods of measurement and some final thoughts about encouraging both innovation in monitoring and evaluation and use of data once collected.

6.1 Which indicators should we consider for the guidelines?

49 indicators were described in this review, each one potentially reflecting changes in 8 impacts that could be stated as goals by a DPM intervention (it is expected that most DPM interventions would identify with only 1-3 impacts at any one time). Not all indicators were equal, varying in terms of their validity (ability to truly measure change in the impact they were supposed to be reflecting), reliability (whether repeated measures would produce the same result) and feasibility (can this indicator be measured with methods that are possible to perform in most locations). The last quality is particularly important to the ICAM Coalition as we are focused on those communities that are resource limited and need cost-effective impact assessment.

In the following table each indicator has been assessed for whether the literature suggests it is valid, reliable and feasible; and finally whether this indicator deserves further consideration for the guidance document. *Please note this is a generous and inclusive judgement at this stage, further whittling down will be required to make the guidance document more focused on the most meaningful and cost-effective indicators. However I would prefer to confer with collaborating partners and ICAM Co members before striking further indicators off the list.* The following DPM evaluation-specific definitions are used in the table:

Do we know if this indicator is valid?

- Yes: 2 or more studies have used this indicator to evaluate DPM
- Not tested sufficiently – Only used once to evaluate DPM
- No - Never used in evaluation of DPM

Do we know if this indicator is reliable?

- Yes - Tested either for inter-observer reliability or reliability over (short) time
- Not tested - No reliability testing described
- No - Tested for reliability and failed on either inter-observer or over time reliability

Do we know if this indicator is feasible? (with our target resource limited locations in mind)

- Yes – Methods described to measure indicator could be completed by one person working fulltime for a maximum of 2 weeks once per year and does not involve expensive tests. Please note that this includes being able to complete a short focused questionnaire, which may be too generous!
- Border line – Either there is a test involved that is relatively expensive, the method is difficult to conduct (requires extensive training), or the time involved would be 2-4 weeks full-time for one person (this would include long questionnaires)
- No – Involves an expensive test or requires greater than 4 weeks of one person full-time

Impact	Indicators reviewed	Do we know if this indicator is…			Consider for guidelines?
		…valid	…reliable	…feasible	
Improve dog welfare	Body condition score	Yes	Yes	Yes	Yes
	Visible skin condition	Yes	Yes	Yes	Yes
	External parasites; fleas and ticks	Not tested sufficiently	Not tested	Yes	No
	Open wounds	Not tested sufficiently	Not tested	Yes	Yes
	Transmissible venereal tumours	Not tested sufficiently	Not tested	Yes	Yes
	Canine infectious diseases	Not tested sufficiently	Yes	Borderline	Yes
	Levels of cortisol	Yes	Yes	No	No
	Fetal resorption and litter size	No	Not tested	Borderline	No
	Dog-dog aggression	No	Not tested	Yes	Yes
	Amicable social behaviour (includes play)	No	Not tested	Yes	Yes
	Dog-human interactions (positive and negative)	No	Not tested	Yes	Yes
	Qualitative behaviour assessment	No	Not tested	Yes	Yes
Reduce/stabilise dog population size/density/demography	Estimates of absolute dog population size (number of dogs within defined area or dogs per km^2)	Yes	Not tested	Borderline	Yes
	Relative indexes of dog abundance/density (number of dogs on set routes or dogs per km street surveyed)	Yes	Not tested	Yes	Yes
	Dog:human ratios (or dogs per 100 people)	No	Not tested	Yes	Yes
	% lactating females	Yes	Not tested	Yes	Yes
	% puppies	Yes	Not tested	Yes	Yes
	Estimates of mortality	Yes	Not tested	Yes	Yes
	Estimates of fecundity	No	Not tested	Yes	Yes
	Age structure	No	Not tested	Not tested	Yes
	Immigration	No	Not tested	Yes	Yes
	Ratio males:females	No	Not tested	Yes	Yes
Improve care provided to dogs	Performance of specific dog care behaviours	No	Not tested	Yes	Yes
	Acquisition of dogs; proportion adopted	Not tested sufficiently	Not tested	Yes	Yes

	Proportion of the dog population that was confined for all or part of the day	No	No	Yes	Yes
	Increase in purchase of pet food	Not tested sufficiently	Not tested	Yes	Yes
	Owner engagement in the intervention	Not tested sufficiently	Not tested	Yes	Yes
	Owner willingness to pay for services	Not tested sufficiently	Not tested	Borderline	Yes
Reduce risks to public health	Number of dogs bites/post-exposure treatments (PET) provided	Yes	Yes	Yes	Yes
	Number of dog rabies cases	Yes	Yes	Yes	Yes
	Number of human rabies cases	Yes	Yes	Yes	Yes
	Number of dog bites (regardless of PET)	Yes	Yes	Yes	Yes
Improve public perception/satisfaction of dog health/welfare/risk/nuisance	Various attitude statements each potentially an indicator	Not tested sufficiently	Not tested	Yes	Yes
	Summative acceptance of dogs score	Not tested sufficiently	Not tested	Yes	Yes
	Prevalence of feeding ownerless dogs	No	Not tested	Yes	No
	Reported adoption of dogs from the street	Not tested sufficiently	Not tested	Yes	Yes
	Dog-human interactions (positive and negative)	No	Not tested	Yes	Yes
	Reported number of type of problems caused by dogs	Not tested sufficiently	Not tested	Yes	Yes
Improve shelter performance	Annual live release rate	Yes	Yes	Yes	Yes
	Intake rates and breakdown of ages	Yes	Yes	Yes	Yes
	Net rehoming rates	Yes	Yes	Yes	Yes
	Footfall	Yes	Yes	Yes	Yes
	Net rehoming:footfall ratio	Yes	Yes	Yes	Yes
Reduce negative impact of dogs on wildlife	Presence of dogs within designated wildlife areas	Yes	Not tested	Yes	Yes
	Number of observed wildlife kills by dogs	No	Not tested	Borderline	No
	Population numbers and structure of wildlife prey	Not tested sufficiently	Not tested	Borderline	Yes
	Incidence rate of rabies/CDV in both dogs and susceptible wildlife	Yes	Not tested	Yes	Yes

	species				
	Proportion of the dog/wildlife population with CDV antibodies	Yes	Not tested	Borderline	Yes
Reduce negative impact of dogs on livestock	Number of livestock predation events by dogs	No	Not tested	Yes	Yes

6.2 Next steps for maximising cost-effectiveness in methods of measurement

The guidance document will need to recommend not only indicators but the most cost-effective methods of measuring these. The following is a brief statement on how each method of measurement could be approached in the guidance document:

- Questionnaires: we could identify a limited number of key questions that form a core questionnaire. Identify (or develop) tools for data capture at the time of interview and also to support analysis, for example tablet apps.
- Participatory research methods: a process and set of exercises would need to be designed by us as there are no dog-specific exercises to follow. This approach could replace some of the attitude statements usually included in a questionnaire.
- Street surveys: we could highlight that absolute estimates of population size are not required for monitoring and recommend that more cost-effective relative indexes are used instead, with attempts at absolute estimates consigned to baselines (when this is truly essential) using a combination of intensive and rapid surveys. Street surveys could also provide much of the data needed for welfare indicators for roaming dogs. This is a method where phone app tools may be very useful due to inherent GPS coordinate capture and real-time data entry.
- Cohort studies: a statistically valid sample size will be too resource consuming for most locations but a mini-cohort may be suitable for exploring otherwise invisible processes
- Secondary sources of information: possibly the most resource light approach to data collection so we could identify pitfalls and how to mitigate these to maximise useful data
- Owner interview/dog clinical exam during intervention throughput: we could identify useful data that could be collected at this time and database tools for maintaining this data in a form that allows for later analysis.

6.3 Study design and subsequent analysis

Reviewing the literature exposed an array of approaches to study design and data analysis; some complex, some straightforward and some poorly understood! It was also clear that many data doesn't make it to interpretation, reporting and learning stages because methodological design made the data unusable or resources for analysis were not available. Hence it would seem wise for the guidance to include some basics on study design, including but not limited to; controlled studies (including the concept of randomised controlled trials, although we may be a way off seeing these in DPM), sampling (random and stratified), replication, confounding variables and data analysis. See Boone & Slater 2013 for an example, in this case focused on cat population monitoring.

6.4 Using the results of Monitoring &Evaluation (M&E)

The guidance document may need to include some discussion on the application of M&E to ensure data are actually utilised in a beneficial way. The reviewed literature exposed limited discussion on how impact assessment had influenced intervention policy and practice (although this may have been done extensively but not reported). Hence including the concept of project cycle management and the particular position of evaluation and learning in the cycle would seem a sensible.

Some discussion of communicating the results of impact assessments both internally and externally may be beneficial. This is where combining indicators to produce composite scores per impact may be useful. However, this approach would be best supported by the guidance if we also suggested how the data relating to each indicator could be reduced to a comparable scoring system (for example a 10 point scale); this is likely to be beyond the scope of this first guidance document.

Although detailed guidance on conducting economic analysis will be beyond the scope of this guidance we could include an example(s) of how indicators can provide impact data alongside intervention cost data to produce cost-benefit/cost-effectiveness analysis.

6.5 Encouraging innovation

The review has exposed a relatively large number of indicators relating to DPM and application of most methods of measurement in some form to dog populations; this is credit to the researchers and DPM managers for persisting in much needed monitoring and evaluation. However many of these indicators have only been used once or twice and often in similar dog populations so their validity is arguable and they fall short of being termed 'standardised'. In recommending indicators and methods of measurement we hope to catalyse an increase in efforts to evaluate DPM, but we will need to also leave space for, and indeed encourage, innovation. The NGO-IDEASs project may provide some learning for our project; it is run by a large coalition of NGOs in Germany and global south, and produced participatory tools for impact monitoring of human development. It was meant to involve 90 groups but grew to 850, part of their success was perceived to be their use of recommended tools with case studies but also their welcoming of innovation which maintained motivation and improved the tools (Causemann & Gohl 2012). Our guidance will similarly be best 'yet' practice and we will need to facilitate feedback to allow innovation and novel applications to be captured and feed into future updates.

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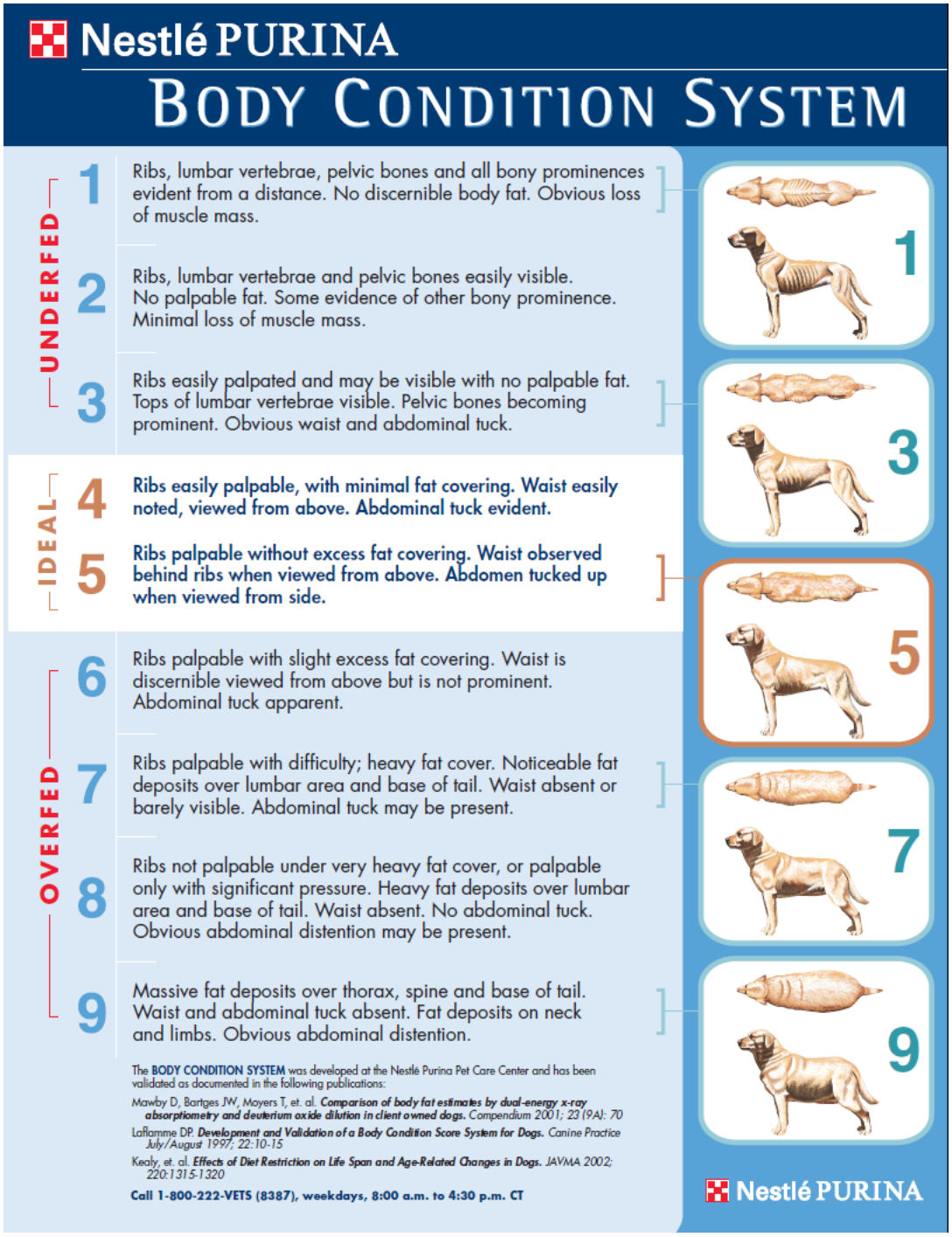
9 Appendix 1 – Purina 9-point body condition score scale



10 Appendix 2 – Body condition score scale used by WSPA in Colombo, Sri Lanka – including photos provided by Darryn Knobel

Body condition score is based on 4 main body areas, check each one in turn to assess score:

- → **Backbone** – if clearly visible score 1, if not visible check ribs
- → **Ribs** – if clearly visible score 2, if not visible check abdominal tuck
- → **Abdominal tuck** – if clearly visible score 3, if just visible score 4, if not at all visible score 5, then double check by viewing waist from above
- → **Waist from above** – if clearly visible score 3, if just visible score 4, if no waist score 5

1) **EMACIATED** - Ribs, backbone, pelvic bones VISIBLE FROM A DISTANCE. No body fat.

2) **THIN -** Ribs easily palpated and visible on close inspection. SOME BODY FAT PRESENT. Abdominal tuck evident. Waist visible from above

3) **IDEAL -** Ribs palpable but NOT VISIBLE even on close inspection. Waist easily visible from above. Fat readily palpable over kidneys.

4) **OVERWEIGHT -** Ribs palpable with excess fat present. Waist barely visible from above. Abdominal tuck apparent.

5) **OBESE** - Ribs barely palpable. Waist absent. Large

1

2

3

4

5