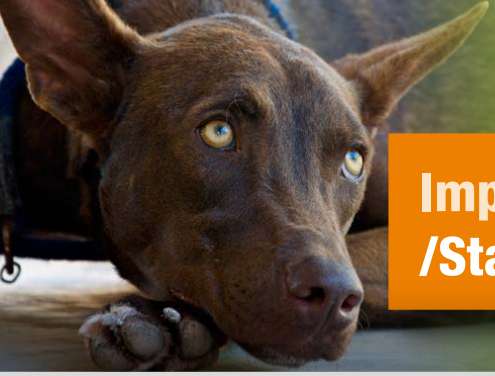


Impact 3: Reduce Dog Population Density /Stabilise Population Turnover

International Companion Animal Management Coalition

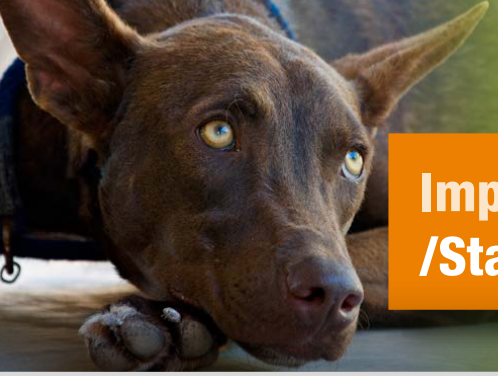
Online Tool Summary PDF

Indicators

Dog density along surveyed streets	Dog population estimates	% of lactating females
Annual survival of roaming dogs	Age structure of roaming dogs	Litters per female
Annual survival of owned dogs	Age structure of owned dogs	% pregnant

Methods of Measurement

Household questionnaires	Street surveys
Clinic records	Secondary sources of information
Behavioural observation method	Sales figures from local vendors
Participatory research methods	Data submitted by rehoming centre
Street surveys and questionnaires for measuring vaccination coverage	Collaboration between wildlife and dog stakeholders for data collection



Impact 3: Reduce Dog Population Density /Stabilise Population Turnover

International Companion Animal Management Coalition

Reducing dog population size or density is commonly stated as a desired impact of DPM. This is targeted towards roaming or 'stray' dogs, as opposed to wanting to reduce the overall dog population. Stabilising the population, also termed reducing population turnover, may also be desired (reducing births and deaths, with each dog living longer on average). Reduced turnover could confer welfare benefits (e.g. fewer puppies being born and dying) and it may also be useful for disease control; if vaccinated dogs live longer, and fewer (naturally susceptible) puppies are born, the proportion of the population that is immune to the disease (termed *herd immunity*) will remain higher for longer, providing a better barrier to disease transmission.

Recommended indicator – Dog density along streets

The indicator of the **number of roaming dogs per km (or mile) of street surveyed** is an indicator of dog density and is preferable to an estimate of total roaming dog population size (also known as abundance) or density estimates based on area. Firstly, it may be an ideal reflection of the public perception of the roaming dog 'problem'; although the average citizen has no concept of the total number of dogs roaming in their town, they have a very real experience of the number of dogs encountered on the way to work or on their children's journey to school. Further, urban areas often both expand and become more dense (losing open spaces to more streets and associated housing) leading to changes in the total dog population that was beyond the influence of any DPM intervention and may be imperceptible to the average citizen. However the average number of roaming dogs along streets will correlate with the chance of an average citizen coming across a roaming dog as they travel along the streets and hence remains a valid indicator of the impact of the intervention. Comparisons can also be made of the average number of roaming dogs per km of street surveyed between locations and perhaps most importantly how this number is changing over time, allowing interventions in different locations to be compared in terms of how they impact on dog density. Finally, measuring the number of dogs per km of street surveyed can be done relatively easily compared to establishing an accurate estimate of total population size.

The Section 'Street surveys' describes a method of observing dogs along a set of standard routes. These surveys can measure the number of dogs seen and their visible welfare state using the indicators introduced elsewhere in these guidelines (i.e. body condition score and skin condition score). Street surveys are then repeated over time (recommended every 6 or 12 months), using exactly the same routes and the same counting protocols, to establish how this indicator of number of dogs is changing. It is important that data from the same time of year is compared, as roaming dog numbers and welfare can vary with season. Keeping the time of day of observation consistent is also very important, as this indicator is actually the number of dogs per km of street surveyed at *a particular time of day,* and the number will change throughout the day as dogs respond to movements of people, traffic and change in environmental temperatures. The best time of day for street surveys is peak roaming time, usually at dawn when traffic is lightest.

In some cases, an estimate of total roaming dog population size will be needed, perhaps most commonly ahead of planning a new intervention. An estimate of population size is not required for monitoring and evaluation of intervention impact and so is not discussed in any detail here, but see Annex D for more information on conducting population size estimates.

Annex D: Calculating Dog Population Size

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

In the section on the impact of reducing dog density, the indicator of dogs per km (or mile) of street surveyed was introduced as an accessible measure of dog density that could be monitored over time. However, in some cases an estimate of total population size will be desired, for example when planning and intervention after which density alone will be sufficient for monitoring.

The simplest approach is to multiply the average number of dogs per km of street with the total street length for the area in question, this street length is usually accessible from local government records or from Geographical Information System (GIS) maps (exclude lengths of motorways and trunk roads when calculating total street length, as roaming dogs are very unlikely to be found on these road types). If the routes used for the street survey were within administrative areas for which there is data available on factors potentially related to roaming dog density (such as the number of detached houses or socioeconomic factors relating to housing provided by recent censuses), such factors can be tested for their relationship with the number of dogs seen on the routes. Route length is included as a covariate first and then factors tested for their additional predictive value using multiple regression. If significant covariates are found these can be used along with route length to refine the estimate for areas that were not surveyed but for which data on covariate factors exist. This method will provide the total number of dogs seen roaming at the particular time of day that was chosen for surveying and not the total roaming dog population; as some dogs will have been missed by the observers and others will roam at other times of the day.

To establish the total roaming dog population a *detectability estimate* will be needed - this is the chance that a dog that roams was seen and recorded by the observers conducting the street survey. The detectability estimate can then be used to 'correct' the estimate calculated from dogs per km of street surveyed and total street length to a total estimate of population size.

Establishing detectability requires more intensive survey effort, using either questionnaires of owners to establish the number of owned dogs that are allowed to roam or mark-resight experiments (see explanation that follows). Because these methodologies are more intensive, the rapid street survey method described for measuring the number of dogs per km of street surveyed can be used widely and then, in just a sample of areas, the more intensive method is used in addition to the rapid method to establish the total population of dogs in that area. The estimated population size in that area from the rapid survey can be compared to the estimate from the intensive survey, exposing the underestimate produced by the rapid survey:

$$\textit{detectability estimate} = \frac{\textit{rapid street survey estimate}}{\textit{intensive survey estimate}}$$

Which intensive survey methods to use?

The most suitable method for intensive surveying depends on the proportion of the roaming population that are unconfined owned dogs rather than unowned dogs.

Roaming owned dogs - questionnaires

If almost all roaming dogs are owned, the most efficient approach is to use a questionnaire which asks owners about the number and confinement of their dogs. This results in an estimate of the average number of dogs per dog owning household that are not always confined (i.e. are allowed to roam for at least part of the day/night), and the total number of dog-owning households in the area. One reason to avoid questionnaires and use the following method of mark-resight is where owners have reason to be dishonest about confinement, for example if there is a local ordinance requiring dogs to be confined.

Unowned dogs – mark-resight

In some countries or regions, for example in India, it is evident that a significant proportion of the roaming population is unowned. If tolerance of and resources for unowned dogs are sufficient to allow some of their pups to survive to sexual maturity the unowned population will exist at a density determined by the carrying capacity in that region. Even in areas where resources are insufficient to allow any pups born on the street to survive to breed themselves there may be enough abandoned dogs and their surviving pups to form a significant proportion of the roaming population, perhaps only seasonally in tourist areas. If unowned dogs do form a significant proportion of the roaming population then the size of that proportion will be unknown, in which case some direct estimate of the size of the roaming population via intensive street surveying is required using mark-resight methods.

If the sample areas selected for the intensive surveying are small enough to deal with in their entirety there will be no need to define sub-sample regions. The approach is to conduct an initial survey in order to mark a known number n_1 of randomly selected dogs, either with an artificial mark such as a paint spray or collar or by photographing distinctive natural markings. If the sample areas are contained by boundaries that are meaningful to dogs, such as the boundaries of a village, marking can be done throughout the village. If the boundaries have no meaning to dogs and they are likely to cross them, such as the boundaries of a municipality within a town, the streets used for marking should be far enough within the boundaries to avoid any of the dogs in the marked sample having moved out of the region by the time of the second survey. During a second survey of all the streets (including those streets up to the border of the area if any were initially excluded for marking) one or more days later n_2 dogs are seen, of which m were included in the n_1 sample. The ratio m/n_1 is the fraction of marked dogs that were on the streets at the time of the second survey and is assumed to equal the fraction of all roaming dogs that were on the streets at that time. Dividing the second survey street count n_2 by that fraction gives the Peterson estimate of the total number of dogs, which can also be calculated as follows:

$$\frac{n_1 n_2}{m}$$

If the sample areas selected for intensive surveying are too large to survey along all streets, a sub-sample of smaller regions may be used, preferably pre-existing regions such as wards or health post regions. Ideally this sub-sample is selected randomly but avoiding any of the selected regions having common borders (WSPA (2007) provides a method for random selection of regions whilst avoiding common borders). The survey method used within each

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

sub-sample region is then as described above for the entire sample area. The abundance estimates for the sub-sample regions are then used to estimate abundance over the whole sample area, either by summing the estimated dog population for the regions and dividing by the fraction of pre-existing sub-sample regions surveyed (Horvitz and Thompson, 1952) or by using a regression estimator to exploit any covariates of the abundance estimates that may be available for each of the pre-existing regions (the common practice of extrapolating by area is an example where area is used as covariate but a poor one because region area and dog abundance are usually not strongly correlated).

Another opportunity to apply mark-resight to large sample areas is to use the standard routes established for the dog density street surveys. By marking (or photographing) dogs along at least a sample of the standard routes, the fraction of those seen on a second survey of the same route can be used as a detectability estimate. Just as in the Petersen method, the proportion marked is upwardly biased (leading to an underestimate of total dogs) as a result of heterogeneity but is now also subject to a bias in the opposite direction because in conducting the second survey only along the standard route we may have missed some of the marked dogs that were roaming at that time but were on other streets.

If the intervention itself involves marking dogs, for example with collars or paint to show a dog has been vaccinated or with an ear notch to show it has been sterilised, then these intervention marks can be used for mark-resight (for example, as used in Hiby et al. (2011) Animal Birth Control (ABC). This may be particularly relevant if the intervention coverage, i.e. the proportion marked, is also required to evaluate the effectiveness of the intervention (see the section on estimating rabies vaccination coverage). This will require consistent and accurate data collection on intervention effort; specifically the number of dogs marked, on what date and in which area they live. It may also require an estimate of mark loss, as collars may fall off or be removed and paint wears off over time. Survival of the dogs will also be relevant in the case of a permanent ear notch that has been applied some months or years previously. Accounting for mark loss and survival will provide an accurate estimate of the marked population that currently exists. One option is to reduce the time between applying the marks to resighting so that the mark loss and mortality can be assumed to be zero; i.e. limiting the days between vaccination and coverage estimation. For an intervention where survival is the relevant factor, resighting for ear notches will be best done in the first weeks and months of the intervention.

The Petersen method suffers from the need to assume that all dogs that roam are equally likely to be seen. That assumption is unlikely to hold because of behavioural differences between dogs affecting when and for how long they are visible on the streets. As a result the abundance estimates are likely to be biased downwards (underestimating the total population), particularly if surveys are conducted at the same time of day.

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

Extensions of the Peterson method that use multiple subsequent surveys to reduce the variance of the estimator include the Schnabel method (Schnabel, 1938) as used by Beck for roaming dog abundance in Baltimore, USA (Beck, 1973) and the Schmacher-Eschmeyer method as used by Totton in Jodhpur, India (Totton et al., 2010). As in the Peterson method, the dogs seen during each subsequent survey are classified into those that have, and have not, been previously marked (i.e. paint marked or photographed) but the size of the marked sample is increased by marking some or all of the unmarked dogs seen during each survey. If marking is by photography, only dogs that have distinctive natural markings are photographed in order to facilitate the classification process. However these extensions require the same assumption as the Peterson method (i.e. that all dogs that roam are equally likely to be seen) and suffer from a similar level of bias if this assumption fails, so it would seem more efficient to use the Peterson method in a larger sample of regions rather than expend the available effort on multiple subsequent surveys.

If the risk of bias is not acceptable, an alternative is to conduct a sequence of surveys and establish the 'encounter history' of each dog seen (for example 0 1 0 1 1 representing a dog first seen on the second of five surveys and then seen again on surveys four and five). Encounter history can be analysed using models of type M_h or M_{th} (Otis et al., 1978) to incorporate variation between dogs in the probability of being seen (referred to as 'heterogeneity' in the mark recapture literature) or variation in that probability both between dogs and from survey to survey. For example Belsare and Gompper (2013) used program CAPTURE to run the jackknife estimator model of type M_h on encounter history data from six villages in Maharashtra, India to estimate the number of roaming dogs in each village.

Such models are likely to reduce bias as compared to the Peterson method, depending on the source of variation in the probability of being seen. Intuitively, information on that variation is available from the numbers of dogs seen very frequently and the number seen only once in comparison to the numbers expected if all dogs were equally likely to be seen. As expected, Belsare and Gompper (2013) report higher estimates using the jackknife estimator than those obtained using Beck's method, which gave point estimates below the minimum population size (as determined by independent surveys) in each village.

However it is time consuming and complicated to establish the encounter histories. The dogs have to be identified as individuals so marking via a paint spray cannot be used. Some dogs do not have distinctive natural markings that allow them to be identified from photographs and descriptions, for example 23% of dogs collected for spaying in Jaipur are uniformly black or tan coloured (Reece, *pers. comm.*). The photographs only establish encounter histories for the distinctively marked dogs so that the resulting abundance estimate has to be corrected by dividing by the proportion of dogs that are distinctively marked. During the surveys, each dog seen has to be recorded as distinctively marked or not and be photographed only if it is distinctively marked. The criteria used to decide if a dog is sufficiently distinctive must remain consistent between surveys. If an observer's ability to distinguish dogs increases over time, there is a risk that a dog will be defined as identifiable and photographed in later surveys and recorded as not having been seen before, whereas in fact it was seen but was considered insufficiently well marked in those early surveys when the observer was less confident. Although encounter histories are likely to reduce bias they do require significant time and effort, limiting the area that can be covered by this approach and brining in other potential biases linked to small sample sizes. This suggests simple Peterson estimates using artificial marks or photographs is the method of choice in most cases.

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

Reduction in dog population turnover

Recommended indicator - Lactating females

An important component of dog population turnover is fecundity, i.e. the rate of reproduction. Puppies only have time-limited passive immunity from their mothers for a short period after birth, hence they are more susceptible to disease and its subsequent transmission, making them an important factor in disease control. This limited immunity also contributes to their high morbidity and mortality, so their welfare is also often compromised. However, reliably measuring the number of puppies in a roaming dog population can be challenging. Puppies are difficult to spot due to both their small size and also because they spend some of their time confined to a den; in addition when they are spotted they tend to occur in clusters with their litter mates. These factors combined means the observable percentage of puppies in a population vary considerably from survey to survey. In comparison, the **percentage of lactating females in the roaming dog population** is a more reliable statistic because lactating females are easier to spot and do not appear in clusters. Hence lactating females are an indicator of fecundity in the roaming dog population and a proxy for the number of puppies.

The percentage of lactating females can be measured as dogs come through an intervention clinic by using clinic records, although this may depend on the intervention; some veterinary surgeons may discourage owners and catching teams from bringing lactating females for sterilisation. However the percentage of lactating females in the roaming dog population can also be efficiently measured during the same street surveys used to measure the number of dogs per km of street surveyed and associated welfare indicators. More details are provided in the Section 'Street surveys' under methods of measurement.

The percentage of lactating females should be calculated as the percentage of *all* females that are visibly lactating as this represents the reproductive activity of the roaming dog population. As opposed to the percentage of only unsterilised females that are lactating, which is unlikely to change with the intervention unless there is a significant change in the resources available to the remaining unsterilised females. The percentage of lactating unsterilised females can be monitored in addition if breeding is suspected to be resource limited in the intervention location, although this would require sterilisation status to be clearly visible, e.g. where ear notches have been used by the intervention to mark sterilised dogs.

A female is defined as lactating if her mammary glands are visibly swollen. Teat size may not be a reliable sign of lactating as females that have had previous litters may show enlarged teats. Females in the very late stages of pregnancy may also show enlarged mammary glands just before giving birth; because this is also a sign of active breeding these females can be included in the category of lactation to simplify surveying.

Reduction in dog population turnover

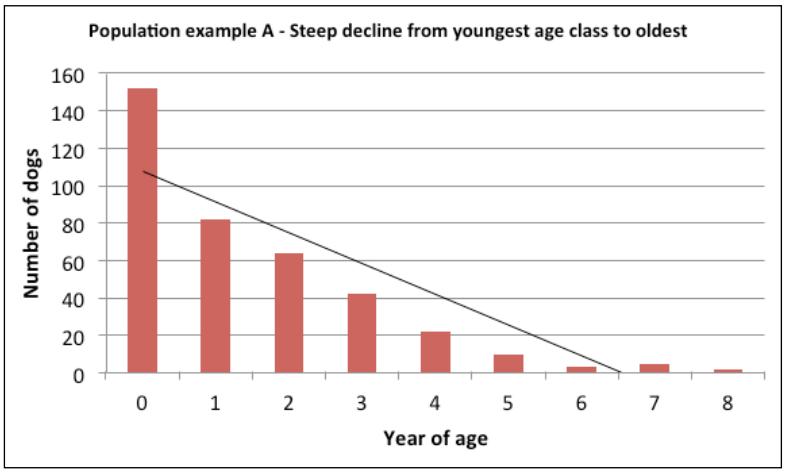
Suggested indicator – Mortality and age structure

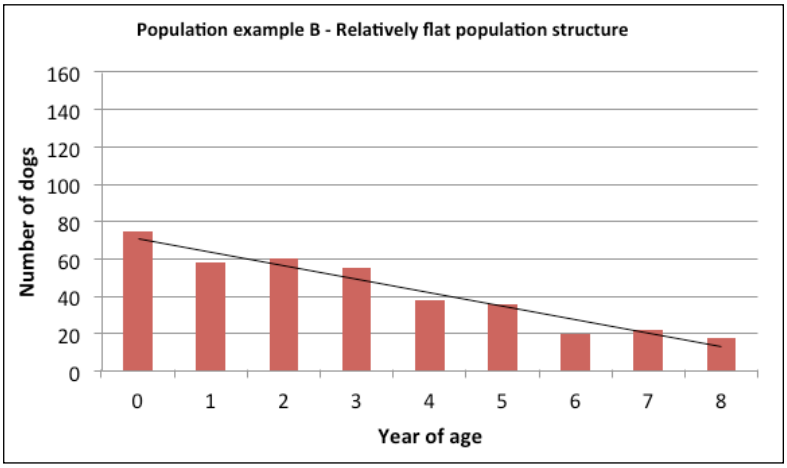
Population turnover also includes the component of mortality. For disease control, increased longevity of vaccinated dogs can help maintain herd immunity, whilst for animal welfare short lifespans are often accompanied by high mortality, morbidity and associated suffering. The indicator of mortality is usually expressed as the opposite statistic, **annual survival**. Examples of using changes in annual survival as an indicator of intervention impact could not be found hence it is described here as a *suggested* indicator only. Measuring mortality/survival is possible using different methods depending on the ownership status of the dogs.

When considering a population of owned dogs, owners can be asked via a questionnaire the ages of their dog (leading to an 'age structure' of the population), how many dogs have left their household in the previous 12 months and what was their fate (e.g. given away, died, disappeared, etc.). Questionnaires and the analysis required for calculating survival are included in Section 'Questionnaire surveys'.

If the target population is comprised mostly of unowned dogs, calculating mortality requires a longitudinal study and marking of dogs with individual marks such as tattoos or microchips, usually applied during a sterilisation intervention. A sample of dogs are re-caught, ideally again as part of the intervention, for example for booster vaccination or deworming, and their individual marks read. These marks are then used to look back into clinic records to the date when each dogs was sterilised. This provides a random sample of minimum times for which dogs survive in the population following the first intervention and marking event, and hence provides information on their survival rate. Using clinical records and re-catch data to calculate survival is described in the Section ''Clinic' records'.

A potential alternative to measuring mortality is to measure **age structure of the population and specifically the proportion of the population that is comprised of older dogs** (these can be defined as 5 years old and above, but can be adjusted to local dog demography). When a dog population has high turnover it will be comprised of a large number of young dogs and relatively few older dogs, as turnover reduces the proportion of older dogs should increase. Data relating to age structure is commonly presented as a histogram of the number of dogs falling into age classes (this may also be called an *age pyramid* when data from males and females are presented back to back). These graphs can show sharp declines from the youngest age class down to the oldest class when turnover is high and a flatter shape with more equality between age classes as the population stabilises. For example, in the following graphs the same population size of dogs are shown with different age structures - example A shows a steep decline from the youngest age class down to the oldest with very few dogs, whilst example B shows a flatter shape with more equality between the age classes:





Kii (1982) suggests that the regression coefficient, a number which represents the slope of the regression line created by age pyramids can be used as an indicator of how a population is changing in age over time. (In humans in the developed world, the histogram can actually start to reverse with relatively large groups in the older classes and relatively few people in the young age classes; sometimes termed an inverted pyramid). With an owned dog population, the number of dogs falling into each age class can be found using a questionnaire, allowing the use of relatively small age classes with ranges of 1 year. Note that there is some evidence that reliability of age reporting reduces as dogs get older (Chris Baker, *pers comm.*) and so the oldest dogs may be best combined into one larger group of 5 year olds and older. However, where street surveys are used, the age classes could be as broad as puppies, adults and old adults, with old adults defined by several physical characteristics including grey muzzle, thickened skin, heavy eyebrows/sunken eyes, hairless patches and stiff gait. This would require discussion and agreement between the survey team as this category is particularly subjective. No examples using age structure, or more specifically the proportion of old dogs in the population, to assess the impact of an intervention could be found, hence this is described at this stage as a *suggested* indicator only.

Where questionnaires have led to detailed age structures with age classes of 1 year increments, the median age of the population can also be calculated. The **median age of dogs** can then be compared over time, or between treatment and control groups, and tested for significance using a Mann-Whitney Test, which looks both for differences in median and spread, essentially for whether one sample tends to have higher values than the other.

Reduction in dog population turnover

Suggested indicator – Litters per female

The **number of litters per female dog per year** is an indicator of fecundity that can be estimated for the owned dog population by using a questionnaire survey. Not all interventions will be aiming to affect fecundity of the owned dog population, as the puppies produced by owned dogs may well be wanted, however this could be a relevant indicator for locations where unwanted litters of owned dogs are a problem. As described for the indicator of pregnant females, litters per female may change with an improvement in the health status of females, with more litters carried to term and females having litters at a younger age.

Section 'Questionnaire surveys' describes this method of measurement in more detail, including a section on how to calculate this indicator from responses to the sample questionnaire in Annex E.

Reduction in dog population turnover

Suggested indicator – Pregnant females

The **percentage of pregnant females in the intervened population** may be used as a potential indicator of fecundity, an important component of population turnover. However, no examples of its use could be found and hence it is presented here as a *suggested* indicator. It is possible that as the health of the population improves so the proportion of unsterilised females that become pregnant and carry a litter to term will increase, similarly the age at which dogs become pregnant may also decrease as their health status improves. In populations of dogs that show strongly seasonal breeding (e.g. in northern India where dogs show a peak in whelping in November; Reece et al. 2008) an additional peak in seasonal breeding may become apparent as either dogs become recruited to the breeding population earlier than one year old or perhaps start to have second litters within one year.

Assessing pregnancy by sight alone may be unreliable; however pregnancy can be assessed at the time of clinical examination (depending on the stage of pregnancy) or during surgical sterilisation. Hence a review of clinic records will provide data for estimating the percentage of females pregnant per month and how this has changed over time. See Section ‘‘Clinic’ records’.

Methods of Measurement: Questionnaire Surveys

International Companion Animal Management Coalition

Questionnaire surveys

Questionnaires comprise a set of standardised questions that can be in closed (questions with a limited set of answers to choose from, such as 'yes' or 'no') or open format (questions that allow the respondent to answer in their own words). This is a well-tested methodology for collecting data relating to a range of indicators. They are relatively time consuming to deliver and analyse and so tend to be used infrequently for DPM evaluation and more often appear as part of initial in-depth assessment of dog populations ahead of intervention planning. However, dependent on the sampling frame and method used to select respondents, they can provide reliable estimates relating to the wider population and so may be useful for evaluation where resources allow. Annex E provides a sample questionnaire that has been based on DPM questionnaires that have been field-tested in several countries. It has been designed to be as short as possible and yet still to collect data relating to indicators mentioned in this guidance document. However, adding extra questions relevant to your intervention location is welcomed. Note the questions in Annex E have been phrased to ask about the performance of actual behaviours, such as stating how often a dog is fed rather than a subjective assessment of whether the feeding is regular or not. Further, multiple choice answers have been included to help with data analysis with all likely responses listed, including a 'don't know' response to avoid forcing the respondent to guess.

Note that when using questionnaires you should ask respondents for their permission to use their data, you should also explain how their name (if asked) will be used. The questionnaire in Annex E starts with a statement to read to respondents and a place where their permission can be recorded.

Relevant Impacts

Questionnaire surveys can be used to measure a wide range of indicators related to several impacts. These include several indicators of improving dog welfare such as body condition score, skin condition and female : male ratio (where the target dog population is visible in households as opposed to on the street); indicators for improving care provided to dogs, including specific dog care behaviours performed by dogs owners and knowledge and attitudes of children following education interventions; under the impact of improving public health the indicators of dog bites and also dog vaccination can be measured using questionnaire surveys; and finally, indicators of an improvement in public perception including attitudes towards dogs and the adoption of dogs can be measured through questionnaire surveys.

Sampling

Questionnaires designed to measure changes in human behaviour over time ideally follow a consistent sample (a 'cohort') of households, hence are longitudinal as opposed to cross-sectional in design. This is because cross sectional questionnaires use a new sample of people at each point in time (a 'point sample' of people), it is difficult if not impossible to select equivalent samples, and the differences in people's background can influence reported behaviours and attitudes, hence you may not be measuring a change in attitudes over time but the difference in the attitudes between the two samples of people chosen. Many factors could influence peoples' attitudes towards dogs and the way their dogs are kept, including gender, religion, degree of education and previous experience of owning an animal as a child. As it is difficult to control for all these factors during analysis, or to ensure the sample contains exactly the same representations of these different types of people, the most robust approach is to ask the same households for their dog care behaviours in order to assess how these have changed over time. This will require the initial sample to be larger than required for final analysis, to allow for dropout but still retain a sufficient sample size; reasons for dropout include people moving away from the intervention area, people losing and not replacing dogs and fatigue with the study. The potential problem with a longitudinal approach is that a change in dog care behaviour may occur in sample households as a result of being observed through repeated questionnaires, rather than in response to the intervention.

Where a longitudinal approach is not possible, a cross sectional questionnaire survey is the alternative. A larger sample size may be needed for a cross sectional approach to increase the chance of a representative and equivalent sample being selected each time. A larger sample size is also needed detect significant change, as analysis will be on different people ('subjects') at different time periods ('between subject' design and analysis), rather than on the same subjects at different time periods ('within subject' design and analysis). The 'between subject' differences at different time points may mask effects due to the intervention; a larger sample size of subjects at each time point can help to expose those effects. The same sampling method and frame should be used to select households at each cross-sectional survey event. For example, every 3rd house along every street in the intervention area, or cluster sampling where all houses in a sample of areas drawn from a larger sample are approached. Examples include the WHO Expanded Programme on Immunization cluster-survey technique, used in dog-related questionnaires by Davlin and Vonville (2012) and Kongkaew et al. (2004). Attempts should also be made to ensure the socioeconomic background of each sample is the same; this can be achieved by 'stratifying' the sample for socioeconomic status in the same way at each survey event (in a 'stratified' sample, some dogs or people have a known greater chance of being selected than others, this is used when your target population clearly appears as sub-populations with important differing characteristics related to your impact, see Section 'Making your impact assessment robust' for more details). This can be achieved by drawing samples from geographical areas of known socioeconomic status (data on age, education and general socioeconomic status by area can be available from census data).

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

Recruitment of respondents

Recruiting a sample of respondents can be done in a number of ways, and the best approach to use will depend on the location and objective of the questionnaire survey. If using a longitudinal questionnaire to assess changes in dog care behaviour in a consistent sample of households, a face-to-face interview at the doorstep may be the best approach to limit dropout. One potential limitation of the door-to-door approach of recruitment is that it may be biased towards those people that are at home most often, such as young families, the elderly and unemployed. Administering questionnaires in the evenings and weekends can help to avoid this bias.

Door-to-door recruitment is also suitable when using cross-sectional approaches but it can be quite time consuming, especially if looking to include a large number of dog owners in an area where dog ownership is relatively uncommon (for example, in urban areas where dog ownership may be <10% of households; e.g. 7% in costal urban communities of Tanzania (Darryn L Knobel et al., 2008)). One approach available when using cross-sectional designs is to use 'convenience sampling': accessing respondents where people are most numerous and accessible, such as at bus stops, on buses, in parks or outside places of worship. The limitation of this approach is that you may be accessing a biased sample of people; however this could be seen as a benefit if an objective is to assess changes in peoples' perception of roaming dogs, which may be best asked of people spending time in public spaces where roaming dogs occur. One benefit of this approach is that selecting a quota of respondents based on visible factors such as age and sex becomes possible, by approaching people within those categories until the desired balance has been reached (e.g. to match the demographics of the location and therefore increase the chances of this being a representative sample).

Another potentially easily-recruited and therefore convenient sample of respondents is children at school (although some countries do have regulations about conducting questionnaires of children and so appropriate approvals must be sought). Depending on the access to education in the locality, children attending a range of secondary schools could still represent a range of socioeconomic and religious groups, although this approach restricts the sample to households with secondary-school aged children. Children of secondary-school age may both be able to fully comprehend the questions in the questionnaire and may well be involved in their family's dog care, but these assumptions would need to be tested in each location.

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

Accessing respondents through landline phones has been a viable method of recruitment in the past, however many countries are experiencing an increase in the proportion of households with mobile phones only, leaving this method open to increasing bias. Access through the internet is a very cost-effective method and also benefits from immediate data entry into a database if respondents are filling in questionnaires online. However, as with mobile phones, the use of the internet is increasing overtime and hence your sample may also change over time, which may confound the effects you are aiming to detect. Postal questionnaires can be used for both longitudinal and cross-sectional designs but this requires a fully literate population of people to avoid biases. A low return rate should be expected for postal surveys.

Any method of recruitment can suffer from bias resulting from only people interested in dog-related issues agreeing to respond. This can be particularly problematic when using methods that do not include face-to-face recruitment, as the rate of responses can be very low (although incentives can be used to increase response rates such as entry into prize draws). As these methods are being used to assess changes in dog care and perceptions over time such a bias may not be too much of a problem, so long as the demographic of people with an interest in dog-related issues does not change over time. Recording response rates to questionnaires can help monitor changes in people's interest.

Interviewer bias

Interviewers can unintentionally affect responses, for example through 'social desirability' where the interviewee provides the responses they think the interviewer wants to hear or attempts to create a particular perception of themselves; this may be done consciously or unconsciously. Avoiding this completely can be difficult; basic differences between interviewers can be relevant, including gender and age, and even without an interviewer present, the respondent may make assumptions about the desired responses based on where the questionnaire has come from (e.g. the sender email address or website hosting the questionnaire). Interviewers and question phrasing need to appear as neutral as possible and all interviewers should use a set script to both introduce themselves and ask the questions to avoid differences resulting from their phrasing. Consider not having staff or anyone publicly identified with an intervention conducting the interviews to maintain objectivity. If this is not possible, be sure to train your interviewers how not to unintentionally affect the responses, they may need to wear neutral clothing (i.e. no logos) or consistently wear the same logo every time the questionnaire is conducted. Using a team of students as interviewers (with the same gender and age composition at each survey event) may be a good option, as they may appear to interviewees as less of an authority figure to appease with appropriate responses.

Health and safety

The safety of interviewers is extremely important to consider especially when using face-to-face interviews. The potential risks involved should be reviewed for every location and mitigated as far as possible. Examples of mitigation include interviewers working in pairs, stopping before sunset, having access to a mobile phone, transport and a supervisor close by to assist when required and check everyone in and out of the survey event. Interviewers are themselves also responsible for behaving appropriately, for example by assessing each house before knocking (if concerned, they can miss out a household and record where, when and why this was done), being polite but not overly friendly with respondents, politely refusing invitations to enter households, dressing appropriately, carrying official ID and halting an interview early if they are concerned (recording where, when and why this was done). In some countries personal alarms may also be available for interviewers to carry with them.

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

Agreement with attitude statements

Monitoring changes in perceptions or attitudes towards dogs can be done through repeated surveys that ask people for their level of agreement with dog-related statements. People are presented with both positive and negative statements relating to dogs, such as “dogs add happiness to people’s lives” and “street dogs pose a danger to people”, and are asked to what extent they agree or disagree with the statements. Their level of agreement is indicated on a scale, called a ‘Likert scale’ (see Annex E for examples of Likert scales), and can later be translated into a score allowing for comparison over time.

Sample attitude statements

Annex E includes four lists of attitude statements that have been used in different environments: one in Colombo, Sri Lanka where both owned and unowned dogs are found roaming (Sankey et al., 2012); one in Tanzania where the roaming dog population is comprised of majority owned dogs allowed to roam freely, these statements were designed specifically for dog owners (Knobel et al., 2008); one to compare attitudes between UK and Japanese students (Miura et al., 2000); and one that was used to compare the attitudes of 4 year old children towards dogs in three European countries (Lakestani et al., 2011). Any of these attitude statement lists can be selected and used as presented or can be adapted to a new location – note the attitude statements for children are for use in a classroom situation as opposed to during a household questionnaire.

The process of adaptation for the adult attitude statements could include using two or more focus groups comprised of local people (both dog and non-dog owners) to discuss the statements and their suitability to the location. Irrelevant statements are then removed and ambiguous ones made clearer using locally relevant terms/phrasing. The groups can also be asked whether there are other important dog-related issues not covered and new statements covering these aspects devised. This new list should then be piloted on 20+ people of varying backgrounds and opinions. Following the pilot test results, the list can be updated further and retested, or accepted in its current form. Note that conducting this process of adaptation may require accurate translation into the local language. This can be done translating the English statements into the local language, and then back-translating into English to check for retention of meaning. This procedure is repeated by revising the statement in the local language until the back-translation matches the original English version.

For interventions that have the resources and access to relevant expertise, a novel set of attitude statements can be developed (e.g. as described in Knobel et al. (2008)). In brief, one potential process is to start with qualitative/open discussions about dogs within focus groups from which a long list of attitude statements can be developed. These are then trialled on a pilot group of 20+ people, either individually or in groups, to remove or amend statements to improve understanding of their meaning. The improved list is then piloted on a larger group (involving twice as many people as you have attitude statements), followed by factor analysis of the results. Factor analysis will expose any statements that appear redundant which can then be removed to make the final list shorter. Additional stages of testing reliability can also be run, including testing statements with the same people but over time.

Analysis of changes in attitudes over time

Attitude statements are commonly presented in lists of over 10 items, to allow for measurement of a range of attitudes and several statements deliberately testing the same issue. This can create problems at the analysis stage: if every statement is individually analysed for change over time there is a chance of finding a falsely significant result (i.e. the score for a statement can differ from its previous score purely by chance. The likelihood of this happening for any one statement increases with the number of statements tested). Hence analysis of these statements can involve making a prior selection of key statements or combining statements to reduce the number of statistical tests conducted. Three different approaches to analysis are described here. The most suitable will depend on resources available for analysis and the level of interest in specific attitudes.

One approach to analysis is to focus on individual key statements within a list of attitude statements. Selection of statements as key to the intervention can be done in two ways. Firstly, the results from pilot testing can indicate statements that are particularly good for capturing variability in perceptions, i.e. not everybody gave the same responses. These statements may be particularly good at exposing changes in attitudes over time as there is 'space' for the data to show statistically significant change. Secondly, statements for which there is a logical explanation for how your intervention will lead to a change in this attitude plus a change in this attitude would be considered important to various intervention stakeholders, i.e. it is a relevant attitude to your work. An example might be an intervention that aimed to reduce dog bites and improve perceptions of dogs through a combination of rabies vaccination, reproduction control and education in safer interactions with dogs; this intervention might in particular want to look for changes in people's agreement with the statement "stray dogs pose a danger to people".

The attitude statements can also be combined into a summative score for acceptance of dogs. For example, from the attitude statements developed in Colombo, Sri Lanka, 10 statements are clearly either positive or negative with regards to acceptance of dogs (statements 2, 4, 5, 7, 11, 12, 13, 14, 16, and 18). Scores of 1 to 5 can attributed for how each interviewee responded to each statement; with a score of 1 for the response 'strongly disagree' with the statement and a score of 5 when the response was 'strongly agree' with the statement. The scores of negative statements are reversed (i.e. statements 4, 7, 13 and 16) so that all of the individual item scores have the same direction, which allows an overall score to be calculated indicating acceptance of dogs. Within this scoring system, a minimum score of 10 would mean total non-acceptance and a maximum score of 50, total acceptance of dogs. Note that this summative score does assume equal weighting to all attitude statements, which may not be accurate, with some attitudes more important than others. Consider using expert opinion to weight the statements as more or less important and use these weighting to adjust the scores; for example using the 'Delphi technique' to systematically achieve a degree of consensus of opinion between experts (e.g. as used by Whay et al. (2003) to find consensus between experts on the best measures for the welfare of dairy cattle, pigs and laying hens). Summing the scores may also mask changes in specific attitude statements, hence this method is ideally used in addition to considering changes in key indicator statements.

Factor analysis is a statistical method used when faced with a large number of observed variables (in this case, responses to a large number of attitude statements); it explores the correlation between these many variables to find a lower number of unobserved composite variables called factors. For example, this was used to analyse the responses to 47 attitude statements about dogs along 7-point Likert scales presented to UK and Japanese students

(Miura et al., 2000). Changes in responses to all 47 statements should not be analysed over time, as this would lead to some significant results just by chance (even with a significance level of 5%, this equates to one significant result out of 20 tests appearing just by chance). So the 47 responses were analysed for how they correlated with each other using factor analysis; this exposed clusters of responses that correlated. Each cluster is called a factor and is given a suitable name depending on what responses it contains. For example responses to the 4 attitude statements "I think that stray dogs are a problem in this country", "I think that stray dogs tend to bite", "I think that stray dogs create a nuisance" and "I think that there are too many dogs in this country" were found to correlate and were given the factor name 'dislike of stray dogs'. Five factors were found to underlie the UK responses and 7 in Japan, including factors described as 'unconcern/concern for hygiene', 'dislike of stray dogs', 'acceptance of dogs as equals', and 'acceptance/unacceptance of euthanasia'. Each statement can be given a score depending on the average position of the responses along the 5 or 7-point Likert scale. Scores for all statements falling within each factor can then be combined to give a score for each factor. These factor scores can then be analysed for changes over time by combining statements in the same way at each survey.

Using questionnaires to estimate fecundity

Questionnaire surveys can be used to estimate the number of litters per female per year, a measure of fecundity. In the sample questionnaire in Annex E, owners are asked of all their female dogs 'how many litters has she had in her lifetime?'; hence every female dog will have a breeding history, although for many this will be 0 litters so far in their lifetime. For every female dog, her average litters per year since she reached the age of 1 year (assumed to be the age of sexual maturity) can then be calculated (i.e. total number of litters for that female / number of years since reaching age 1). The average fecundity for the female population is then calculated as the average litters per year for all females of 2 years and above; only those females of 2 years and above are included to ensure they have experienced a full year of potential breeding after reaching the age of 1 year. The assumption of 1 years old as the age of sexual maturity can be tested by calculating the average age at first litter; the question 'How old was she when she had her first litter?' is also included in the sample questionnaire.

The average number of litters per female can also be further extended to the average number of puppies per female per year, an alternative indicator of fecundity. The average litter size can be calculated from responses regarding fate of puppies born in litters produced in the previous 12 months (the sample questionnaire in Annex E includes the following question to capture this data: 'if she has had a litter in the previous 12 months, please tell us about the fate of all puppies from this litter', followed by nine outcomes). The number of litters per female per year is then multiplied by the average litter size to calculate the average number of puppies per female per year.

Using questionnaires to estimate survival

Questionnaire surveys can be used to estimate survival of owned dogs as part of either a longitudinal or cross-sectional study. A simple estimate of current adult survival is available by comparison of the total number of adult dogs owned a year ago with the number owned currently that are at least 12+*m* months old, where *m* is the minimum age in months at which a dog is considered as adult (e.g. 5 months). The respondents are asked "over the past 12 months, did any of the household's adult dogs die or leave the household?" From the responses, the proportion that have died or disappeared can be estimated, leaving out those dogs that have been sold or donated to other people and which may still be alive. There may be cases where the fate of dogs that have left the household is unknown, however this is likely to be a relatively small number and the proportion estimated from the dogs with known fate can be applied to the total number of dogs that left the household, allowing the total number of dogs that have died or disappeared in the last 12 months to be estimated. The number of adult dogs that have died or disappeared in the previous 12 months is then subtracted from the number owned a year ago and the remainder (representing the number of dogs that have survived the previous 12 months) divided by the number owned a year ago to estimate adult survival.

An alternative approach is to estimate the age structure of the current owned population (split into equal age groups of one year) by asking the respondents the current age of their dog, or when and at what age each dog was obtained. In a population that is either constant or that has been growing at a constant rate for some years (perhaps in line with the growth of the human population) the age structure will have stabilised to the point where the number of dogs a years old divided by the number $a-1$ years old equals S_a/λ, where S_a is adult annual survival at age a and λ is annual population growth rate of dogs. Although annual survival will be reduced in very old dogs survival of owned dogs that are allowed to roam is probably low enough for the number of dogs that reach that advanced age to be negligible. In that case an estimate of an age-independent adult survival probability S is available as the average ratio of the size of successive adult age groups multiplied by λ.

Survival of pups is certainly not independent of age. Whereas respondents may not be able to provide reliable data on the age at which adult dogs died, those owning dogs that have recently had a litter of pups may be able to remember the age in weeks or months at which any pups died. Age-specific survival can then be estimated using the Kaplan-Meier method (Kaplan and Meier, 1958), which does not assume a stable age structure (important as any seasonality in breeding would destabilise pup age structure) and allows individuals whose survival is unknown (because they were sold or given away) to be accounted for in the analysis. The ages at which pups were known to die are listed sequentially. Just before each of those ages there is a number of pups known to have reached that age (pups sold or given away before that age are excluded from that number). The number of pups that died at that age is then subtracted and the remainder (representing the pups surviving beyond that age) are

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

then divided by the total number of pups known to have reached that age. That provides an estimate of survival over the interval since the previous age at which one or more pups died. Multiplying those estimates up to a specific age provides an estimate of pup survival to that age.

Tools available to implement and analyse questionnaires

Conducting questionnaires can be relatively time consuming and so tools to reduce the different processes involved are potentially very useful. Questionnaires can be designed on survey sites such as Survey Monkey (www.surveymonkey.com) and then, if internet access is sufficiently reliable, the responses can be filled in on a mobile phone or tablet during face-to-face interviews (note, any drop in internet access would mean halting the interview until connection is re-established). This avoids the need for printing forms and transcribing data from forms to computer later, and it also offers some basic analysis features. If internet access is not reliable, there are applications for phones and tablets that allow for data entry even when offline, for example Device Magic (www.devicemagic.com), SurveyToGo (www.dooblo.net) or Open Data Kit (www.opendatakit.org).

Annex E – Sample Questionnaire

Date: _____ Interviewer: _____ Interview no: _____

District: _____ Ward: _____ Street: _____ House no/name: _____

Household GPS reading Latitude: _____ Longitude: _____

Type of structure: ☐ Single/detached house ☐ Attached house ☐ Flat
☐ Row house ☐ Hut/Shanty ☐ Compound

'Starter question' (defines time commitment): Does your household own a dog?

'Own' is defined as a dog living in the house or yard most of the time and being fed by the household on a regular basis.

☐ NO ☐ YES

Ask the respondent if you can ask further questions. State:

> *"Your answers to these questions, and those of other people we ask, will be used to help us understand the dog population better. There are no right or wrong answers to these questions, so please answer as accurately as you can and you can skip any question that you do not wish to answer. Your name and address will remain confidential and will only be used to identify where in ___ you live and to find your house again if we need to ask follow up questions in future"*

If he/she owns a dog tell him/her that the interview will take up to 20 minutes.

If he/she does not own a dog tell him/her that the interview will take up to 10 minutes.

Permission received? ☐ Yes ☐ No

☐ YES, but please come back later
What day/time? _____

If YES, go to Question 1.1

SECTION 1 – HOUSEHOLD INFORMATION

1.1. First, some questions about you;

Name: _____ Gender: _____ Age: _____
(age can be recorded as 'adult' or 'child' if they don't want to give their exact age)

What religion are you?: ☐ None ☐ Muslim ☐ Christian
☐ Hindu ☐ Buddhist ☐ Other _____

1.2. How many people live in the household? _____

1.3. Does the household feed any dogs that are not your own on a regular basis *(regular basis defined as at least once per week)*?

☐ NO ☐ YES ☐ Don't know

SECTION 2 – DOG BITES

2.1. Was anyone in the household bitten by a dog within the last 12 months whilst physically in _____*? *(*Refer to intervention area)*

☐ NO ☐ YES ☐ Don't know

If **yes**, provide details of the dog bite below:

What is the sex of person bitten?	What age were they when bitten?	Bitten by which dog?	Do you know the age and sex of biting dog?		Do you know why the dog bit?	How did you treat the site of the bite, if at all? (include all relevant responses)
			Sex	Age		
		1. Own dog 2. Owned dog from the community 3. Unowned dog from the community 4. Unknown strange dog 5. Don't know			1. Yes, answer suggests provocation 2. No, answer suggests bite was unprovoked 3. Don't know	1. Wash the wound with water only 2. Wash the wound with soap and water 3. Go to the bite centre/ hospital 4. Nothing 5. Other? (please describe) 6. Don't know

If asking for agreement with attitude statements include them here for non-dog owners and at the end for dog owners.

If the household does not own a dog, please thank the respondent for their time and ask if they have any questions before leaving.

If the household owns a dog go to Question 3.1.

SECTION 3 – HOUSEHOLD DOGS

3.1.

	Adults > 3 months			Puppies < 3 months		
	Total	M	F	Unk	M	F	Unk
How many dogs are there living in this household?							
How many dogs were in this household 12 months ago?							

Over the past 12 months, did any of the household's adult dogs die or leave the household?
(only for adult dogs, puppies of under 4 months are included in female breeding history table only)

☐ NO ☐ YES ☐ Don't know

If yes, please record the details of all adult dogs that have left the household in the last 12 months in the table below:

	What sex was the dog?	What happened to him/her?	How old was he/she when this happened?
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

1. Male 2. Female 3. Don't know	1. Sold 2. Given away 3. Killed by owner 4. Killed by authorities 5. Killed by someone else 6. Died in accident 7. Died of disease/ parasites	8. Died through starvation 9. Died other 10. Disappeared 11. Abandoned/ Disowned 12. Stolen 13. Unknown

Ideally, how many dogs would you like in your household? _____

3.2. Household adult dogs information *(only for adult dogs currently owned by household, puppies of under 4 months are included in female breeding history table only)*

Dog no.	Name?	Sex?	Age? (be as precise as possible)	Sterilised?	Breed?	Where did you get this dog from?	Age when acquired?	What is the main role or function of this dog?	Who looks after the dog?
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
		1. Male 2. Female 3. Pregnant fem 4. Lactating fem 5. Don't know		1. Yes 2. No 3. Don't know	1. Pure bred 2. Pure-bred cross 3. Mongrel 4. Don't know	1. Pup of own dog 2. Bought inside ____* 3. Bought outside ____ 4. Gift from inside ____ 5. Gift from outside ____ 6. Adopted off the street 7. Adopted from shelter 8. Other (specify) 9. Don't know		1. Guard household 2. Protect livestock 3. Protect crops 4. Pet/companion 5. Hunting 6. Breeding 7. Other (specify) 8. Don't know	1. Respondent 2. If not respondent, age & sex of household member 3. Don't know

* ____ Refer to intervention area

3.3 Household adult dog care *(includes welfare scores if dog can be seen)*

Dog no. (as in table 3.2)	Is the dog confined?	How is the dog confined?	Access to shelter when confined?	Has dog been vaccinated? If yes, how long ago?	Has dog been dewormed? If yes, how long ago?	Has dog been treated for fleas/ticks? If yes, how long ago?	How often is dog fed by your household?	What kind of food?	Was this dog given fresh water yesterday?	Body condition score?	Skin problem?
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											
9.											
10.											
	1. All day only 2. All night only 3. All day & night 4. Sometimes 5. Never 6. Don't know	1. Compound/ yard/garden 2. House 3. Kennel 4. Static chain 5. Running chain 6. Other (specify)	1. Yes, all the time 2. Yes, but not all the time 3. No 4. Don't know	1. Yes, and number of months/ years 2. Never 3. Don't know	1. Yes, and number of months/ years 2. Never 3. Don't know	1. Yes, and number of months/ years 2. Never 3. Don't know	1. Twice a day or more 2. Once per day 3. Once every 2 days 4. Less frequently than once every 2 days 5. Don't know	1. Commercial 2. Home-made 3. Leftover human food 4. None 5. Don't know	1. Yes 2. No 3. Don't know	1 2 3 4 5 6. Dog not visible	1. No 2. Yes 3. Dog not visible

3.4. Female breeding history (please include all female dogs, if a female has never had a litter the answer to the second question will be 0 and the rest of the table can be ignored as the follow-up questions are for breeding females only)

Female dog no. from previous table				
Is she confined when in oestrus/heat?				
How many litters has she had in her lifetime? (if she was owned by someone else previously, please include litters born with this previous owner)				
Tick if know about full breeding history (no unknown breeding during previous ownership)				
How old was she when she had her first litter?				
Has she had any litters in the previous 12 months?				
If she had a litter in the previous 12 months, in which month was the most recent litter born?				

If any females have had a litter in the previous 12 months, please tell us about the fate of all puppies from the most recent litter for each female:

Female number from previous table_____

Pup no.	Sex	Fate		Age at event
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
	1. Male 2. Female 3. Unknown	1. Still in household 2. Sold 3. Given away 4. Killed by owner 5. Killed by authorities 6. Killed by someone else 7. Died in accident	8. Died of disease/parasites 9. Died through starvation 10. Died other 11. Disappeared 12. Abandoned 13. Stolen 14. Unknown	

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

(Spare page for recording additional litters)

Female number from previous table_____

Pup no.	Sex	Fate		Age at event
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
	1. Male 2. Female 3. Unknown	1. Still in household 2. Sold 3. Given away 4. Killed by owner 5. Killed by authorities 6. Killed by someone else 7. Died in accident	8. Died of disease/parasites 9. Died through starvation 10. Died other 11. Disappeared 12. Abandoned 13. Stolen 14. Unknown	

Female number from previous table_____

Pup no.	Sex	Fate		Age at event
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
	1. Male 2. Female 3. Unknown	1. Still in household 2. Sold 3. Given away 4. Killed by owner 5. Killed by authorities 6. Killed by someone else 7. Died in accident	8. Died of disease/parasites 9. Died through starvation 10. Died other 11. Disappeared 12. Abandoned 13. Stolen 14. Unknown	

SECTION 4 – VACCINATION HISTORY

(only included if using questionnaire to estimate vaccination coverage; question about roaming can be changed to a specific time window when street survey occurs)

4.1 Vaccination coverage estimation

Dog no.	Was this dog vaccinated in the recent campaign?	Was it marked?	Is this mark still present?	Is your dog in the house/yard now?
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
	1. Yes 2. No, already vaccinated 3. No, didn't know about the campaign 4. No, couldn't get there 5. No, don't want my dog vaccinated 6. No, other (specify) 7. Don't know	1. Yes, collar 2. Yes, paint 3. No 4. Don't know	1. Yes 2. No, fell or wore off 3. Don't know	1. Yes 2. No, roaming 3. No, on walk with owner 4. Don't know

If asking dog owners for agreement with attitude statements include them here.

Please thank the respondent for their time and ask if they have any questions

Attitude statements used in Colombo, Sri Lanka

Based on questionnaire used to assess the dog population in Colombo, Sri Lanka by Blue Paw Trust and WSPA (WSPA, 2007b).

1. Having a dog is a waste of money:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

2. I like dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

3. Dogs should always be kept outside the house:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

4. I don't like being close to dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

5. Dogs add happiness to people's lives:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

6. People who own dogs should spend time every day playing with them:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

7. If a dog of mine got a skin disease, I would not want it around the house:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

8. If a female dog of mine had a litter of puppies, I would not want to keep any of them:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

9. A person should treat their dog with as much respect as they would a human member of the family:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

10. A dog is a valuable possession:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

11. Street dogs should be looked after by the community:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

12. The welfare of street dogs is important to me:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

13. People should not feed street dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

14. I like having dogs around on my street:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

15. Dogs should have the same rights and privileges as humans:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

16. Street dogs pose a danger to people:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

17. Street dogs should not be allowed to breed:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

18. It is not acceptable to kill dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

Attitude statements used in Tanzania

Attitude statements developed and used as part of a questionnaire survey to assess the attitude of dog owners towards their dogs in 12 sites across Tanzania (Knobel et al., 2008).

1. Our dog/s is/are a valuable possession:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

2. Our dog/s is/are an important part of the household:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

3. We like owning a dog:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

4. Our dog is a member of the family:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

5. You should treat your dog with as much respect as you would a human member of your family:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

6. Our dog/s is/are accustomed to being touched:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

7. Our dog/s enjoy being petted:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

8. We often play with our dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

9. We enjoy our dogs' companionship:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

10. It is unhealthy to touch dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

11. We never touch our dogs:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

12. Our dog will bite us if we touch it:

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

Dog attitude Questions, used in Japan and UK

Based on the dog attitude statements (named the "DAQ") developed for a study of university students in Japan and UK (Miura et al., 2000)

Please indicate how strongly you agree or disagree with the following statements, by drawing a circle around the appropriate number on the agreement-disagreement scale. For example, if you think you disagree with the statement strongly, you might circle the 2 on the left side of the scale. Note the circle can be drawn by interviewee or interviewer can read out statements and ask for level of agreement and circle the correct number on behalf of the interviewee.

Disagree strongly	Disagree	Neutral	Agree	Agree strongly
2	1	0	1	2

	Disagree				Agree
1. I think that there are too many dogs in this country.	2	1	0	1	2
2. I think that the most important role of dogs is guarding.	2	1	0	1	2
3. I think that a dog is 'Man's best friend'.	2	1	0	1	2
4. I wish more hotels would allow dogs to stay with their owners.	2	1	0	1	2
5. I think that dogs cannot live without human help because they were domesticated by humans.	2	1	0	1	2
6. I think that keeping a dog is a waste of time and money.	2	1	0	1	2
7. I think that dogs should be allowed indoors.	2	1	0	1	2
8. I feel sorry for a dog when I see the dog obey every command, because the dog seems to be controlled by the owner.	2	1	0	1	2
9. I think that having a dog increases security.	2	1	0	1	2
10. I think that keeping a dog is annoying to its owner's neighbours.	2	1	0	1	2
11. I think that dogs have personalities like humans.	2	1	0	1	2
12. I think that an owner should look after his/her dog until it dies naturally, if the dog has an incurable illness.	2	1	0	1	2
13. I think that dogs are smelly.	2	1	0	1	2
14. I think that training dogs is a reflection of human arrogance.	2	1	0	1	2
15. I think that owners should keep their dogs (rather than get rid of them) even if the dog has attacked people.	2	1	0	1	2

	Disagree				Agree
16. I think that dogs should be allowed to roam unless they cause problems in human society.	2	1	0	1	2
17. I think that having a dog provides opportunities for meeting new people.	2	1	0	1	2
18. I wouldn't want to keep a dog indoors, because they shed their hair.	2	1	0	1	2
19. I think that only working dogs such as sheep dogs, guide dogs and police dogs need training.	2	1	0	1	2
20. I think that stray dogs should be euthanized.	2	1	0	1	2
21. I think that dogs are happier when kept outdoors rather than indoors.	2	1	0	1	2
22. I wish restaurants would allow dogs to enter with their owners.	2	1	0	1	2
23. I think that euthanizing a dog is cruel.	2	1	0	1	2
24. I think that stray dogs tend to bite.	2	1	0	1	2
25. I wish shops would allow dogs to enter with their owners.	2	1	0	1	2
26. I think that dogs should be chained outdoors.	2	1	0	1	2
27. I think that an owner should let his/her dog run free in public places like parks.	2	1	0	1	2
28. I think that stray dogs create a nuisance.	2	1	0	1	2
29. I think that euthanasia is justifiable if a dog is suffering.	2	1	0	1	2
30. I wouldn't want to keep a dog indoors, because they are unhygienic.	2	1	0	1	2
31. I think that when people get a new dog, they should take the dog to a training class.	2	1	0	1	2
32. I think that stray dogs are a problem in this country.	2	1	0	1	2
33. I think that dogs should have access to all rooms in the house.	2	1	0	1	2
34. I think that having a dog makes it difficult for its owner to travel.	2	1	0	1	2
35. I think that dogs are more loyal than people.	2	1	0	1	2
36. I get upset when I see dogs chained outdoors.	2	1	0	1	2
37. I think that training dogs is cruel.	2	1	0	1	2
38. I think that dogs are unhygienic.	2	1	0	1	2

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

	Disagree				Agree
39. I think that the most important role of dogs is giving people companionship.	2	1	0	1	2
40. I wouldn't want to keep a dog indoors, because they are smelly.	2	1	0	1	2
41. I think that owners should keep their dogs (rather than get rid of them) even if the dog is aggressive to strangers.	2	1	0	1	2
42. I think that having a dog is fun.	2	1	0	1	2
43. I think that dogs should be spayed or neutered to prevent unwanted puppies being born.	2	1	0	1	2
44. I think that dogs should obey their owner's commands all the time.	2	1	0	1	2
45. I think that it is justifiable to euthanize aggressive dogs.	2	1	0	1	2
46. I am interested in TV programs and articles on dogs.	2	1	0	1	2

ACKNOWLEDGEMENTS AND REFERENCES
ANNEX A
ANNEX B
ANNEX C
ANNEX D
ANNEX E

Attitude statements used with 4 year old children in UK, Italy and Spain

Attitude statements taken from Lakestani et al. 2011; original list was 12 statements long but 3 statements relating to dog emotions (e.g. Dogs can be scared of people) were found to reduce reliability of the test and so were removed from further analysis, only the 9 statements that resulted in reasonable reliability are included here. 4 year old children were asked to rate each of the following item as “never”, “sometimes” and “mostly”:

1. Dogs are dirty
2. Dogs can be friends with people
3. Dogs are smelly
4. I love my dog/I would like to have a dog
5. Dogs bite
6. Dogs are scary
7. I like hugging my dog / I would like to hug a dog
8. Dogs are fun
9. I like walking my dog and playing with him/ I’d like to walk a dog and play with it

For positive items, responses were coded as follows: never = 1, sometimes = 2, mostly = 3. This was reversed for negative items. Attitude scores were calculated by taking the mean of these response codes for each child. Attitude scores ranged from 1 to 3, with a high score corresponding to a positive attitude to dogs.

Methods of Measurement: Street Surveys

International
Companion Animal
Management Coalition

Street surveys are an efficient method of collecting data relating to a range of indicators. Their efficiency makes them particularly suitable for monitoring and evaluation because they can be repeated several times over the course of an intervention. The data collected is only related to roaming dogs seen on public property (i.e. not those behind fences or within compounds) and the ownership status of these dogs may not be clear (although a good state of welfare and wearing collars are potential signs of ownership): these roaming dogs may be owned roaming, community owned dogs or entirely unowned dogs either born unowned or abandoned/lost by their former owners. This means that confined dogs will not be accessed through street surveys; this could be a disadvantage but as confined dogs are commonly not a priority target this may be a minor concern for some interventions.

Relevant impacts

Street surveys are most commonly used to measure impacts related to roaming dog density, demography and welfare. Street surveys may also be useful for assessing the coverage of an intervention where the intervention has involved visible marking of dogs, for example collars or paint spray during vaccination campaigns or ear notches during sterilisation. These marks are noted and recorded for every dog observed to assess the proportion of the population that has been reached by the intervention. See the section ‘Street surveys and questionnaires for measuring vaccination coverage’ for the specific use of this method following vaccination.

Method

The method described here involves counting dogs on a route that runs along streets. It is similar in principle to the ‘strip transect’ method of wildlife surveys, in that observers move relatively quickly along an extended line to avoid double counting and to collect information on how animal density varies across the area. The difference to strip transects is that there is no intention to extrapolate the counts to an estimate of abundance rather the concept is to repeat these routes in a consistent manner and compare the counts over time (see Annex D on how estimates of abundance can be calculated if necessary). The method thus depends on protocol consistency; using one or more standard routes at a consistent time of day and year and following a standard counting protocol, for example using a consistent average speed and mode of transport which will affect the ‘search effort’, i.e. the chances you will see a roaming dog through your observational skills. Ideal modes of transport include motorbikes carrying a

2-person survey team, cars and bicycles; walking is generally too slow to allow surveying to be completed within a reasonable timeframe and risks double counting dogs as the survey team will be moving slower than some dogs roam.

Protocol

- The survey team consists of 2-3 people (a driver, navigator and observer, with navigator and observer combined as one role when using a 2-person team, and no driver if using bicycles). However, all members of the survey team are responsible for spotting dogs.
- The team follows the predetermined route (see route selection section that follows) travelling at maximum 15km an hour, slowing or stopping to record every dog seen before moving on as quickly as possible; keeping up a pace is important to avoid double counting and cover the route efficiently.
- Every roaming dog seen on the route is counted. Dogs confined within properties, walking on lead or 'close to heel' are excluded from the survey. In some cases a dog will be inside a fenced area but the gate will be open and the survey team needs to agree a consistent rule about how these dogs will be treated.
- Every dog is allocated to one of 5 categories: male, female, lactating female, puppy (under 4 months), unknown adult. This is extended to up to 10 categories when the intervention includes visible marking, as each of the 5 categories can be marked or unmarked. This falls to only 8 categories when the marks are ear notches applied during sterilisation as lactating females and puppies will not have been through the intervention yet and so can only be unmarked.
- Every dog is also assessed for welfare status and potentially also whether they are wearing a collar (in some countries where tethering is common, dogs on tethers but not confined behind a fence can be included in the survey as these dog are accessible to roaming dogs and so are a relevant part of population in terms of breeding and disease transmission).
- In some cases additional attributes (sex, intervention marks and welfare status) will not be possible to judge accurately due to the dog moving out of sight or lying down. The observers must not guess these attributes but either categorise the dog as unknown or leave welfare status unrecorded (i.e. unobserved) for that dog. Data on these attributes will be obtained from the sample of dogs that can be reliably assessed.

Route selection

Standard routes for the survey can be designed within existing administrative boundaries, such as wards or municipalities, or routes can be drawn randomly across the entire area:

Routes within administrative boundaries ('ward' is used here as a generic term for administrative boundary): One or more routes can be drawn in every ward, however if the area is too large to cover, a sample of wards can be chosen. Routes should be approximately 25 - 30km (15 - 18 miles) long to allow the survey to be completed within 2 hours. They should encompass different road types, excluding only those roads where dogs are very unlikely to be found and surveying would be difficult (e.g. motorways), and also including different environment types such as dense urban areas versus open rural settings falling within the ward. These road and environment types should be included in the route in approximately the same proportion as they appear in the ward. The drawing and saving of routes can be done online using Google 'My Maps'.

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

Routes along random sample of streets across intervention area: If using wards is not possible or not preferred, routes can instead be drawn along a random sample of streets across the entire area of interest. This sample of streets needs to be selected without bias to where dogs are located. One option for selecting the sample is to create a zig-zag track across the survey area. This can be done using Google 'My Maps'; a zig-zag line can be drawn across the whole area using the 'add line' function; then the 'add driving/cycling/walking route' function (dependent on the chosen mode of travel) can be used to create a route that fits as closely as possible to the original zig-zag line. This should create an unbiased route that covers both small and large roads.

Available tools for street surveys

Mobile phone applications (apps) are particularly suitable for street surveys because they can easily be carried by the surveyors, can record Global Positioning System (GPS) information and can eliminate the need for later transcribing of data.

If the Google account used for designing the routes on the computer is synchronized with a smart phone, that phone's Google Maps application can be used to display the route on the phone's screen. The phone can be used first to navigate to the start of the route and then to follow it, by taking the turns required to keep the Maps cursor moving along the displayed route.

A second mobile phone application called 'OSMtracker' (free to download) can be used as an event recorder to record the type and welfare state of every dog seen – note this app can only be used on Android smart phones. OSMtracker also records the time and GPS coordinates of each event so that following download of the data from the phone to the PC the spatial distribution of the dog types can be displayed on a map.

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

Photo: © World Animal Protection

Methods of Measurement: Clinic Records

International Companion Animal Management Coalition

Relevant impacts

Data collected through clinic records can be used to measure indicators relating to dog welfare, dog population stability and care provided to dogs, specifically reflecting owner engagement with the intervention over time. The specific indicators include:

- Indicator of dog health/welfare
  - Reduction in the % of dog with BCS 1 (or BCS 1+2)
  - Reduction in the % of dogs with a visible skin condition (can also include changes in types of skin condition if diagnosis was possible)
  - Reduction in specific diseases targeted by the intervention
  - Reduction in % of dogs with a TVT seen either at clinic exam or during surgery
  - Female:male ratio gets closer to 1:1 – female dogs are no longer neglected/killed as their unwanted litters can now be prevented. Note that if the clinic catches or invites one sex over the other this will bias the sample and the female:male ratio will not be representative of the wider population
- Indicator of population stability
  - Adult annual survival
  - Increase in the proportion of old dogs in the population (old / puppy+juvenile+adult+old); this indicator is only possible to measure with clinic records where the treatment is regular (e.g. vaccination or deworming) and not a one-off, i.e. sterilisation. Where sterilisation is being used the population accessed by the clinic may start to skew towards the younger age groups as the majority of older dogs have already been sterilised
  - Decrease in the % of lactating females or pregnant females and changes in seasonal patterns of breeding.
  - Indicators of the quality and value of the service and also responsible dog ownership by owners
  - Increase in the proportion of dogs that are re-treatments
  - Increase in the number of dogs that are brought by owners or carers rather than caught by staff
  - Increase in the average donation/payment per dog or reduction in the size of the difference between intervention veterinary costs and donations/payments from owners (this takes into account changes in the costs of the intervention)
  - Reduction in the number of unwanted but otherwise healthy dogs euthanised

Questionnaire surveys
Participatory Research
Street Surveys
Secondary Sources
Clinic records
Behavioural Observation
Vaccination Coverage

Biased sample

It should be noted that the dogs coming through an intervention are very likely a biased sample, i.e. they are 'special' in some way. They have come to the intervention for a reason, either to do with their owner, carer or in the case of unowned dogs, dog catchers. This means these dogs may, or may not, be a good representation of all dogs in the wider area and so conclusions about general dog population welfare must be drawn with caution. If the percentage of dogs passing through the intervention is high (e.g. 70% of the dog population is brought/caught for rabies vaccination), this is a very large sample and changes in indicators measured from this population of dogs may be sufficient for monitoring intervention impact without any attempt to extrapolate to the wider dog population. However, any changes to protocol that could impact on which dogs are brought by owners/carers or caught by intervention staff must be noted down and made available during later analysis and interpretation of the data. For example, changes to the messaging about services provided by the intervention may target different type of dogs; for example advertising early age neutering may skew the dogs brought to the intervention towards younger dogs, or advertising free or low-cost parasite treatment may increase the proportion of dogs with skin condition brought to the intervention.

Note that for veterinary interventions much more information may be collected on individual dogs than will be necessary to ensure good quality of care. The following is limited to information that is suitable for monitoring and evaluating population level changes and hence is not an exhaustive list:

Data to collect for each dog

- If the dog is brought by an owner
  - Dog identification, at least name but microchip or tattoo if present and digital photograph if possible (note tattoo character length can be minimised by using an alphanumeric code)
  - Owner name and address, including postcode, borough or ward to allow for aggregation of data to geographical areas
  - Amount paid/donated by owner
- If dog is brought by a carer (they do not own the dog, but they have accepted responsibility for bringing them for veterinary care)
  - Exact address of where they collected the dog
  - Amount paid/donated by owner
- If dog is caught
  - Exact address of capture including GPS coordinates if available (e.g. by using a mobile smart phone)
- Age of dog. Record this as accurately as possible, but at least whether the dog falls into the 4 categories of;
  - under 4 months (puppy)
  - 4 months-11 months (juvenile)
  - 1-5years (adult)
  - over 5 years (old dog)
- Gender
- Reproductive status. Castrated/spayed, unsterilised, pregnant, lactating.
- Body Condition Score. 5-point score (see Annex A)
- Skin condition. Presence or absence of a visible skin condition. Diagnosis of cause if known.
- Any concurrent illness, infection or injury.
- Transmissible venereal tumour (TVT) at clinic exam. Presence or absence of a TVT
- TVT at spay/castrate. Presence or absence of a TVT (it's important to separate TVTs that were discovered during surgery from those that were visible at clinical exam, as the prevalence will differ)
- Treatment provided
  - Is this the first visit for the dog or repeat visit?
  - What treatment was given (e.g. sterilisation, vaccination, deworming, dipping, wound treatment, etc)?
  - If euthanasia, categorise by reason for euthanasia: physically unhealthy, behaviour problem (as perceived by owner to be unmanageable) or unwanted by owner for other reason (i.e. the dog is physically and behaviourally healthy)

Tools available for data recording

Clinic records can quickly become very numerous and therefore difficult to handle, hence a data collection tool is particularly useful. Microsoft Access databases can be developed for specific clinics, including drop down lists to reduce entry error on common terms (e.g. municipalities in addresses, treatment type, gender, reproductive status). Ideally data is entered straight into the database at the clinic; this is supported by having the database hosted on a laptop or on an online system to allow access by several devices, including mobile phones.

There is an Access database available to download for free from www.conservationresearch.org.uk/Home/ICAMCoalition.html. This is designed for recording clinic information from interventions that access unowned dogs for sterilisation and vaccination and was developed to suit the Animal Birth Control (ABC) approach of DPM used in India and includes the data requirements outlined in 'The Standard Operating Procedures for implementation of the Animal Birth Control (ABC) Programme' published by the Animal Welfare Board of India (AWBI, 2009).

Survival estimates of roaming dogs utilising clinic data

Interventions can provide an opportunity to apply a permanent individual mark to a dog, such as a microchip or tattoo; most commonly this will be whilst the dog is anesthetised for sterilisation. After these dogs have been returned to their owners (or the point of handling in the case of unowned dogs) there can be opportunities for a sample of these dogs to be accessed again and their individual marks read. Example opportunities include during booster rabies vaccination; re-catching for treatment or accidentally because a mark has been missed; or re-catching a sample of dogs just to read their individual marks. These dogs will provide a sample of the population that are known to have survived for a specific length of time, from the date the marked dog was released to the date of reading. This is only possible if accurate clinic records have been maintained.

A program can be downloaded and installed to estimate adult survival from a sample of re-accessed individually-marked dogs from www.conservationresearch.org.uk/Home/ICAMCoalition.html. This program also allows for the inclusion of dogs that passed through the intervention in a period of time before individual marking was introduced; these dogs would carry a mark (such as an ear-notch) to show they had been intervened but no individual mark (such as a tattoo). The proportion of these dogs as compared to individually-marked dogs can also be used in the estimate so long as the date of commencing individual marking is known. This was included because interventions commonly do not individually mark successfully from intervention outset. Adult survival is assumed to be independent of age but a stable age structure assumption is not required. Instead we need to know the date of every release of a marked dog since the start of the intervention and whether it was marked as a puppy. We also need to know the date on which individual marking commenced and the date of re-reading the individual mark. In addition to adult annual survival we then need two further parameters, the probability that a surviving released dog is included in the sample (the sampling effort) and a possibly reduced survival for those dogs neutered as puppies – in the computer program referred to previously, these have default start values and precise values are calculated by the program as described later. Those parameters then give the probability of survival and inclusion in

the sample for each individually marked dog and also the expected number of dogs in the sample with an intervention mark (such as an ear notch) but without an individual mark. That number has a Poisson distribution about its expectation whereas the appearance or non-appearance of each individually marked dog in the sample become the outcomes of a sequence of Bernoulli trials and hence combine to form a likelihood that can be maximised with respect to the three parameters. The method has the potential to include covariates of the survival probability, certainly the sex of the released dog if both males and females are included in the intervention but perhaps also factors such as the type of intervention used, e.g. the method of neutering operation used.