Contact Between Dogs, And Between Dogs and People

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy

by

Carri Westgarth

UNIVERSITY OF LIVERPOOL

March 2008

This thesis is based on research carried out in the Department of Veterinary Clinical Science at the University of Liverpool. Except for where indicated, this thesis is my unaided work.

Carri Westgarth

TABLE OF CONTENTS

Contact between dogs, and between dogs and people - Carri Westgarth

Dogs are popular pets in many countries. The interactions that occur between dogs, and between dogs and humans, are of interest to behavioural, welfare, psychological and social sciences. As dogs are a potential source of zoonotic infections to humans, such interactions may also impact on public health. Interactions between dogs, for example whilst walking, may also transfer infectious diseases (zoonotic or non-zoonotic) through the pet dog population. Despite their popularity as pets, there have been no in-depth studies into the contacts that occur between dogs, and between dogs and people; this thesis uses a variety of methodologies to examine these contacts.

A census-based, epidemiological study was used to investigate factors associated with dog ownership and contact with dogs, in a semi-rural community of 1278 households in Cheshire, UK. This study supported the suggestion that dogs are more common in families who have older children (6-19 years), as has been generally observed in other countries. Dog owners were also more likely to have contact with dogs other than their own, compared with those not owning a dog. A questionnaire survey of 260 dog owning households in this community found that the contacts that these dogs have, with people and other dogs, were highly variable and affected by: size, gender and age of dog; individual dog behaviours; human behaviours and human preferences in management of the dog. A number of situations were identified that may be of particular importance in relation to zoonoses, including: sleeping areas, playing behaviours, greeting behaviours, food sources, walking, disposal of faeces, veterinary preventive treatment and general hygiene. Faecal samples were provided for 183 of the dogs and forty-six (25%) were identified, by either culture or direct PCR isolation methods, as carriers of the zoonotic pathogen *Campylobacter upsaliensis.* Multivariable logistic regression identified risk factors for *C. upsaliensis* carriage as: living with a positive dog, living in a household with pet fish, size of dog, age of dog, being fed commercially-bought dog treats, and being fed human food tit-bits (particularly the act of feeding leftovers in the bowl, although letting the dog feed directly from a plate had a protective effect). These results have implications for prevention of *C. upsaliensis* carriage in pet dogs and the subsequent possible transmission to people.

Social network analytical approaches were used to investigate potential networks arising amongst 214 of the dog owning households, through their utilisation of public space during walking. A high level of *potential* contact was demonstrated and this has implications for infectious disease transmission. Most households walked their dogs in only a few areas, but a small number visited many areas. In addition, behavioural observational studies of focal dogs were used to investigate the interactions with other dogs, people and the environment that may occur on dog walks. Dogs were observed to interact with other dogs much more commonly than with people. A multivariable model of percentage duration spent sniffing suggested that day of observation, UK Kennel Club Breed Type and observing urination were important. Whether a dog is kept on a lead or not whilst on a walk could affect the frequency in which it interacts with other dogs and people that it meets. An experimental study of ten dogs was conducted and hierarchical multilevel modelling suggested that lead status of both dogs in an interaction is important in influencing whether or not the interaction will occur; therefore if used as an intervention for reducing disease spread, both dogs should be on a lead. The work in this thesis provides new insight into the dog-human relationship and presents information of use to those interested in reducing infectious disease transmission between dogs, and between dogs and people.

Acknowledgements

A PhD is impossible to achieve without the help and support of others, it cannot be done alone.

I would like to thank....

Rob Christley, Probably the Best Supervisor in the World (if Carlsberg made Supervisors). In particular, for agreeing with me when the other lot had their own ideas.

Ros Gaskell, for infectious enthusiasm, whipping my writing into shape, and many hours of a good Rozzling.

Gina Pinchbeck, for never turning me away when I was stuck on analysis, and for always believing in me. A great role-model and the person I am most chuffed to recieve a compliment from.

Susan Dawson, for the outstanding ability to find typos that five other people have missed, and general essential life-support.

John Bradshaw, for enthusiastically welcoming me into the Bristol team and fuelling my passion for behaviour. I am eternally grateful for the opportunities you have given me.

My interviewers; Thryn, Claire, Lisa and Rob. I apologise for making you stand on endless door-steps on beautiful summer evenings.

Thanks to Karl at Glenbrittle Kennels, and Royal Canin, for providing money-off vouchers.

A big thanks to the dogs and their owners on the Wirral who participated in the study (whether knowingly or not!).

My office-mates over the years: Ruth, Claire, Emily, Debbie, Karen and Jo, and other Epidemiology partners-in-crime: Marnie, Jenny, Marie, Susie and Kathy. Thanks for pep-talks, understanding through difficult times, dog walks, embracing my crazy moments, and volumes of chocolate and cake.

The other members of the Epidemiology Group, and Small Animal Infectious Disease Group, at Liverpool. I feel proud to be a part of these teams, and they are great company on travel adventures, (conference anyone?).

To everybody in Animal Behaviour and Welfare at Bristol, in particular Emily, Nicola and Rachel, for being so warm, friendly and helpful. I must also thank the honours students for putting up with an old codger, letting me have a hoodie, and lending me their notes when I once again got stuck in traffic.

A huge thanks to the people who were unfortunate enough to live with me and the furry-ones: Kathy, for being so... brilliantly German, Jenny – my rock, Helene for putting up with my cat and her food-stealing-escapades, and Jason for welsh chuckles.

Maz, I am lost for words here. Because of you I never feel alone.

Erica Peachey, for sharing her knowledge, giving me purpose, and providing me with so many opportunities and support.

The valuable constructive criticism and opinions of anonymous referees considerably improved the papers that were published from this thesis.

And last but by no means least:

Thanks to my family: my Mum and Mike for endless support (even when I decided to become a dog trainer), my Dad for creating and nurturing the scientist in me, and Tracey for listening to me waffle and always finding time to read (and correct) my writing.

Thanks to Rob, for his friendship, and to Tom, Andy, Buckley and Mike for always putting a smile on my face, a song in my head, and a pint in my hand.

And of course, I cannot forget the dogs in my life:

Jasmyn, my faithful companion and constant source of wonder and marvel at the canine mind.

Logan, for sharing how great life is ...... and bear hugs.

Ben, Sky and Alfie, for making my life more difficult than it needs to be, but reminding me why the world needs me.

The countless Hearing Dogs who inspired me.

And this thesis is dedicated to the memory of Huxley, the dog that sparked the obsession.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

Humans and dogs have lived in close proximity for thousands of years. They were the first species of animal to be domesticated, towards the end of the last ice age (Clutton-Brock 1995). It is surprising how little we know about the domestic dog, considering its huge practical and emotional impact on human lives, whereas the wolf and other wild canid relatives have been studied in far greater detail (Serpell 1995). Through domestication, the dog has moved out of its ancestral niche, to the natural environment of humans, and thus formed close contacts in these heterospecific social groups (Miklosi and others 2004).

It has recently become increasingly apparent that dogs are an important source of zoonotic infections (Greene and Levy 2006). Little detail is known of the nature and frequency of contacts between pet dogs and their owners, or other humans they meet in their daily lives. Equally, little is known of the contacts between dogs that could transmit infection through a population, for example during interactions between dogs whilst walking. Primarily, it is a combination of both human and dog behaviours that determine where the dog goes and what it does, and the subsequent possible mechanisms of disease transmission between dogs and humans and between dogs. Studying these interactions is not only of zoonotic importance, but of behavioural, psychological and social science interest. This thesis aims to investigate features of pet dog ownership and characterise the contacts that exist, using the methods of epidemiology, ethology and network analysis.

1.2 Statistics about dog ownership

In 2004 it was estimated that 1 in 2 households (52.3%) in the UK owned a pet (Anon 2004b): 21.1% of households owned dogs, 24.6% cats, 7.2% birds, 10.4% small animals, 20.5% fish, 1.0% reptiles and amphibians, and 0.9% horses and ponies. Estimates for the USA in 2004 were 62% pet owning compared to only 56% in 1988 (Anon 2004a), indicating an increasing popularity of pets. The UK owns 6.8 million dogs (Anon 2004b) and USA 65 million (Anon 2004a). Across Europe, the percentage of households owning either a dog, cat or bird varies: Belgium 71%, France 63%, Netherland 60%, Italy 61%, West Germany 37%, Ireland 70%, with an average of 52% for all 17 European countries surveyed (Anon 1991). It must be noted that these data were generally obtained via market-research surveys and so may not be completely accurate representations.

In the USA, a number of studies have concluded that pets are more common in families that have children (Beck and Meyers 1996; Franti and Kraus 1974; Franti and others 1980; Leslie and others 1994; Messent 1984; Teclaw and others 1992; Tower and Nokota 2006; Troutman 1988; Wise and Kushman 1984; Wise and Yang 1992) and this association has been generally supported in other countries (McHarg and others 1995). As an exception, a study of dog ownership in Germany found that the majority of the dog owners (over 60%) did not live with children less than 18 years of age (Brand 2002). However this study was conducted in a big city (Berlin) and recruited via dog training schools and vets, and therefore was likely biased towards professional-type people, who had sufficient time and money to own a dog in a large city and take it to training classes, and may be less likely to have children.

1.3 Positive aspects of dog ownership and contact with dogs

1.3.1 Physical health benefits

The effects of pet ownership on human health is an area that has been studied on a number of occasions but has been somewhat inconclusive. Pets probably do confer health and psychological benefits but discovering the mechanism(s) for this benefit has proved more difficult (Headey 2003). Most famously, a positive statistical association was found between pet ownership and one year survival in a sample of 92 coronary outpatients (Friedmann and others 1980); this study was criticised at the time but has since been replicated (Friedmann and Thomas 1995).

Serpell (1991) conducted a longitudinal study on three groups; one that had just acquired a dog, one a cat, and a control non-owning group. The animals were mainly acquired from two local pet shelters and so the cases were not random, but the three groups showed no differences between their perception of health at the beginning of the study. Over a 10-month period a highly significant reduction in minor health problems was reported in pet-owning groups, sustaining the full 10 months for dog owners. Pet-owning groups also improved on a general health questionnaire. No significant changes in health perception were seen for the non-owning group. The observation that differences continued up to 10 months in the dog owning group was taken to suggest that that the changes were not just due to the novelty of a new pet. However, this study design was not blinded or placebo-controlled and it is possible that prior expectations of the effects of pet ownership may have biased the results.

In a survey of dog ownership in suburban Australia, most dogs were walked more than once a week but 31% were walked once a week or less (Kobelt and others 2003). Walking is beneficial to the health of humans, but whether dog owners are actually more active than non-dog owners is uncertain. A survey of 25-64 yr olds in New South Wales concluded that dog owners are generally no more active than non-owners unless they are in a subset of dog owners that practice regular sustained dog walking (Bauman and others 2001). Total average time spent walking for dog owners was only 18 minutes per week more than for non-owners. All dog walker categories (does not walk dog, walks up to 1hr per week, walks 1-2.5 hrs per week) were slightly less likely to reach the 150 minute per week "health enhancing" threshold, than those without dogs, except for those who walked their dog for 2.5 hours or more. In short, owning a dog was only likely to increase health if it was actually walked enough. If all of the dog owners had walked their dog for at least 150 minutes per week the prevalence of people with sufficient physical activity would have increased from 47% to 71%. Serpell (1991) also compared the physical activity of new dog owners, new cat owners and those who did not own pets. At the beginning of the study the dog owners were found to take considerably more physical exercise than the other two groups and this continued throughout the study, suggesting that there is something inherent about people who choose to own dogs also taking more physical exercise.

1.3.2 Psychological health benefits

There are also psychological as well as physical benefits to owning a dog, and the close attachments formed between dogs and people have been documented by questionnaire-based investigations (e.g. Barker and Barker 1988; Serpell 1996). However, there is a lack of reports of behavioural observations of dogs and people interacting (Miklosi and others 2004). Walking creates many opportunities for dog-dog and dog-human contact. One study, alluded to in a different paper but never actually published in its own right, suggested that on lead dogs are more likely to initiate contact with people than off lead dogs (who would rather interact with other dogs or the environment), and that more people initiate contact with on lead dogs than off lead ones (in Bekoff and Meaney 1997).

Walking with a dog has also been shown to facilitate social interactions between people. The benefits of increased social contact could be valuable to groups such as the elderly or disabled. A study by Messent (1983) found a significantly higher number of responses from strangers (such as looking at dog, talking to owner or touching dog) when walking with a dog than when walking without the dog, however this study was only conducted on eight subjects. Study areas included street, subway and park; the park was the strongest area for responses but only if the dog was present.

Facilitation of social contact could be because the dog is an 'ice breaker' for conversation, or that people with dogs appear more likeable, or a combination of both. A similar study (McNicholas and Collis 2000) attempted to control for the dog itself soliciting attention through its behaviour, by using a trained guide dog, but without identification as such so no undue attention was attracted. The study also took place across a number of different environments, although nowhere that would be unusual to see a pet dog. A considerable number of potential interactions were observed over a number of sessions but the study was only performed on one dog. A substantial increase in number of interactions with strangers was observed but the presence of a dog did not influence the length of the interaction which occurred. The effect of 'scruffy' or 'smart' dress (person and dog) with or without the dog was also investigated. The dog was still the most significant factor in the number of interactions observed. The facilitation of social contact is also widely known in Assistance Dogs charities (personal experience and Hart and others 1996).

Dogs and children

There are suggested benefits to children's development from pet ownership. For example a comparison of children with pets and those without described benefits of: 'mutuality'; involvement with another, needing social support, and needing to care about other people or living things (Bryant 1990b). It also has been suggested that through owning a dog, children can learn about friendship, toilet training, sexual behaviour and pregnancy (Levinson 1969, 1972). The bond between child and dog can be strong, and it has been reported that a group of children that interacted with their dog frequently perceived that the dog could understand mood, feelings and speech and liked to talk to their dogs (MacDonald 1981).

Dogs and the elderly

The elderly can also benefit from the perceived acceptance, forgiveness, adoration and unconditional love of a companion animal, at a time when they may be feeling lonely and isolated by decreased mobility or loss of a loved one (Bustad 1983). Introduction of a budgerigar into the life of an elderly person showed improvement in attitudes towards people and perception of own psychological health (Mugford and McComisky 1975). A dog had a stronger social lubrication effect than a budgerigar. The impact of pet ownership on the elderly is important to consider, because as people live longer, the proportion of elderly in the population will increase.

Dogs and the immunocompromised

A proportion of the population is immunocompromised, through agents such as HIV or treatment with immunosuppressive agents during disease treatment (Robinson and Pugh 2002). Immunocompromised persons may also benefit significantly from companionship in this difficult time in their lives. In a study of HIV patients, those who owned pets reported less depression than non-owner patients (Siegel and others 1999).

1.4 Negative aspects of dog ownership and contact with dogs – disease risk

1.4.1 Introduction to zoonoses

Virtually everyone in the community is in contact with either animals, or their products or their excreta (Egerton 1982). Health hazards commonly associated with pets include bites and scratches leading to infection, or allergies to fur or dander. The importance of other diseases which can affect both humans and animals (zoonoses), is also a concern with regard to the pet dog population. Exposure to canine zoonoses may be through direct or indirect contact (Robinson and Pugh 2002). In their definition, direct contact includes; a bite, lick or scratch; urine spray; inhalation of droplets from sneezing or coughing; handling of dog or faeces or reproductive discharges. Indirect contact may occur through the zoonotic agent surviving on an object such as bedding, contaminated food or water, or bites from an arthropod vector (Robinson and Pugh 2002). However, for the purpose of this thesis, I will refer to direct contact as meaning actual physical contact between individuals, or very close proximity, e.g. the dog sniffing another person or dog; indirect contact would be, for example, through contact with excretions such as faeces or contact with bedding. Zoonotic diseases may be due to parasitic, bacterial, fungal and viral agents (as reviewed in Geffray and Paris 2001). There are approximately 30-40 organisms of companion animals that are known to cause zoonotic infections (Greene and Levy 2006).

There are many zoonotic diseases that could be discussed; the examples described here are to illustrate the context within which zoonotic diseases in dogs are an issue. Detail of individual diseases is not of concern in this thesis, only the general methods with which they could transmit through a population or across species.

1.4.2 Parasitic infections

A review of the importance of parasitic infections in the pet population (Robertson and others 2000) discusses the prevalence of parasites, the risk of infection and how to manage and reduce these risks. Over the past twenty years the prevalence of intestinal helminths in dogs has apparently declined and it has been suggested that this is due to increased awareness and subsequent usage of effective drugs, although it could be due to sampling and diagnostic differences. A study of gastrointestinal parasites in dogs in Australia (Bugg and others 1999), found that 82.4% of owners had wormed their dogs in the 12-month period preceding the survey, with the dogs being wormed on average 3.4 times per year. However, these owners were all clients of veterinarians, and probably more likely to treat their dogs for worms than the dog owning population as a whole.

Toxocara canis (a roundworm) is a well known parasitic nematode of canids. Eggs excreted in faeces mature in the soil and subsequently are ingested by humans, typically small children who sometimes perform pica (Tan 1997). Infection can lead to visceral larva migrans affecting brain, liver and eyes. Dog faeces in two Philadelphia parks were examined for disease agents (Rubin and others 1976) and findings included 40% and 19% of soil samples and 30% and 73% of faecal samples containing nematode ova in the two parks. In other areas, soil infection levels have sometimes found to be low, suggesting the possibility of another mode of infection such as ingestion of eggs embryonating in the coat of a dog (Wolfe and Wright 2003).

Both the dog flea and the cat flea use the dog as a host and will also bite man, but do not use man as a host. Fleas may be involved in transmission of the dog tapeworm (*Dipylidium caninum*) to man when the larval fleas ingest tapeworm eggs that develop in the body cavity, and that may very rarely transfer to humans if fleas are ingested. Ticks and mites may also be brought into the house by dogs and attack man (Sampson 1984).

1.4.3 Bacterial infections

Campylobacter

Campylobacter infections are among the most common causes of human bacterial diarrhoeas worldwide (Anon 2000) and account for considerable human morbidity (49803 cases in UK in 2005, DEFRA 2006). Most infections occur through ingestion of contaminated water, milk, or food (Tan 1997). Mostly *C. jejuni, C. coli* and less often *C. upsaliensis* are causes of human campylobacteriosis (Anon 2000), but *C. upsaliensis* is the main species risk associated with dogs and has been isolated from pets including apparently healthy puppies and kittens (Hald and Madsen 1997). Ownership of pet puppies has been reported to be an independently associated risk factor in campylobacter illness in young children in Australia (Tenkate and Stafford 2001). Exposure to diarrhoeic animals has been associated with a three-fold increase in the risk of *C. jejuni/coli* enteritis in humans (Saeed and others 1993). In order to assess the disease transmission risk from pets to humans accurately it is important that the nature and frequency of contacts between pet dogs and their owners and other people are evaluated (Wieland and others 2005).

Epidemiological studies of risk factors for Campylobacter infection in dogs have generally identified age as an associated factor, with younger dogs being at higher risk (Sandberg and others 2002; Wieland and others 2005). However, there were differences between *C. upsaliensis* and *C. jejuni* infection risk factors in the latter study; *C. jejuni* infection was not associated with age of the dog but was associated with regular contact with birds and/or poultry. Both healthy and diarrhoeic dogs may carry the bacteria

(Sandberg and others 2002; Wieland and others 2005). In these studies no positive association was found between infection and diarrhoea; in fact for *C. upsaliensis* a negative association was suggested. The extent to which Campylobacter causes actual disease in dogs is unclear (Baker and others 1999; Burnens and others 1992; Fleming 1983; Lopez and others 2002; Nair and others 1985; Rossi and others 2008; Sandberg and others 2002).

Salmonella

Salmonellosis is a significant zoonotic disease causing gastroenteritis in humans, although less commonly reported than campylobacteriosis in the UK (49803 cases in 2005, compared with 12652 cases of Salmonella, DEFRA 2006). The majority of *Salmonella* cases are derived from uncooked human food in food poisoning cases. Still, some have been linked with pets in the home (Morse and Duncan 1975). Although in the past it has been reported that between 15% and 25% of dogs have salmonellae in their faeces (Marron and Senn 1974), it is currently estimated that approximately 0.1-3.5% of healthy dogs are thought to carry *Salmonella* spp (Fukata and others 2002; Hackett and Lappin 2003; Weber and others 1995). It has been suggested that pet food may be heavily contaminated with *Salmonella* spp. and therefore may lead to contamination of human food when dogs are fed in the kitchen (Christopher and others 1974; Pace and others 1977). However, these reports are relatively old and this data may not apply to modern commercial pet foods, although the recent increasing popularity of feeding raw meat diets may now be a concern (LeJeune and Hancock 2001).

MRSA

Concern for zoonotic potential has recently developed in other bacterial diseases. Methicillin-Resistant *Staphylococcus aureus* (MRSA) has been isolated from the pet dog of hospital workers who were found to be linked with MRSA cases (Cefai and others 1994), and also from the nares of an apparently healthy dog belonging to a patient with diabetes who, along with his wife, repeatedly had soft-tissue MRSA infections (Manian 2003). Only when the dog had been recognised as the re-infection source, and this was eradicated, was further recurrence of infection prevented. After discussion it was discovered that the dog, a healthy female 18-month-old dalmatian, routinely slept in their bed and licked their faces. It was suggested that the dog initially became colonised through contact with the patient who had recently been hospitalised, and then became a source of re-infection. It is currently unknown how many healthy pet dogs in the UK are carriers of MRSA but one small study of dogs in a veterinary referral hospital (which may contain dogs markedly different from the general population) found a prevalence of 9%, even though none were being treated for an MRSA infection (Loeffler and others 2005). Other studies have found evidence of MRSA colonisation in dogs with clinical infections who were being treated in veterinary hospitals, and concurrent isolation from nasal swabs taken from staff, for example (Baptiste and others 2005).

1.4.4 Dog faeces

Canine faecal material is a major potential source of zoonotic pathogens, and humans may be at risk of acquiring these pathogens; owners may be exposed due to faeces on their property, or when picking up and disposing of faeces, and the general public may also be exposed if faeces is left on the pavement and parks. Dog faeces also attract flies and rats which could then transfer organisms to humans (Sampson 1984). In their study of urban dogs in Perth, Australia, Bugg and others (1999) reported that 56% of owners collected and removed faeces from their yards at least four to five times per week. Frequent disposal of faeces and regular worming treatment could reduce the risk of zoonotic disease spread.

It is estimated that 1000 tons of faeces are produced per day by Britain's dogs (Lacey 1994). Despite the widespread existence of local by-laws requiring dog owners to 'clean up', fouling is still observed. One study aimed to find out why some dog owners clean up and other do not (Webley and Siviter 2000). Dog walkers in parks and streets were observed unknowingly and a few minutes later approached and given a questionnaire to complete about their attitudes towards dog fouling and whether they picked up or not. When the questionnaires were posted back the researchers could tell if the interviewee had been 'responsible' (picked up) or 'irresponsible' (left it) on the occasion observed, due to the colour of the paper given. Overall 59% were responsible when observed, (though this rose to 70% when in a park compared to on pavement). Some responsible owners could be re-classified as irresponsible through admitting they had let their dog foul in the past. Fourteen of 36 irresponsible owners claimed that their dog had never fouled, suggesting that self-reporting in this topic cannot be relied upon. There was no difference between responsible and irresponsible in terms of age, gender or price of dog. The main difference between the two groups was a general attitude among irresponsible owners that dog mess is perceived as 'biodegradeable' and 'washes away in the rain'. The authors suggest that many people are unaware of how many dog owners actually remove faeces and the dangers involved with dog faeces, and therefore proposed education as means of tackling the problem rather than fines and laws that were obviously being ignored.

1.4.5 Dog-human interactions and disease transmission

Activities that involve contact of zoonotic disease potential between the pet dog and owner include playing, feeding, grooming, greeting, disposal of faeces and sleeping. The dog may sleep in the bedroom or even share the bed, although in one study, more cat than dog owners admitted to sleeping with their pets (Albert and Bulcroft 1987). In the same study, dog owners were found to spend more time interacting with their pets (grooming, walking) than cat owners. Another study found that dogs were more likely to try to interact with strange persons than cats (Miller and Lago 1990) which suggests that dogs have more of a potential for greeting visitors, which could involve jumping up and licking. In a survey of dog ownership in Australia, jumping up on people was reported as a problem behaviour in 56% of the dogs (Kobelt and others 2003). Of course this may have occurred even more often but was not considered a problem by the owners, or they did not want to report it.

Smith (1983) observed the interactions between dogs and humans in ten family homes. She examined two types of interactions; hand-contacts (such as stroke, rub, scratch or resting the hand on the dog) and play. Play types identified included fetch, keep-away, tug, chase and wrestle, and play often involved a toy. Interestingly it was observed that in childless families the people (adults) and dog interacted more readily, more frequently and more complexly than in those families with children. This was a very limited and small study but suggests that although families with children are more likely to have a dog (see section 1.2), dogs in these families may receive less direct attention than those in households without children. Households without children may be less likely to have a dog, but they are still an important population to consider in terms of zoonotic disease risk, as when they do have a dog they interact with it a lot more than average. This suggestion is supported by findings from another study (Albert and

Bulcroft 1987), where although pet ownership was highest among households containing large families, attachment to pets was highest among people living alone and couples without children at home. Smith's study also noted the differences breed and, more notably, size make; small dogs (4-18 pounds) were more likely to actively contact a person (stand with paws on persons leg or jump on lap), compared to large dogs which were seldom observed to do this.

In a questionnaire survey of dog-owner play behaviour, owners reported playing with their dogs indoors with a median frequency of once per day (Rooney and others 2001). The survey was followed by observational studies of subjects in their houses, whilst they played with their dogs. Behaviours observed included physical contact between dog and person such as: pat dog, tickle, nuzzle dog, kiss dog, pick up dog, shove dog, grab paws and pull tail. The purpose of the study was to investigate how play with a dog is initiated, and physical contact was less successful than other signals, although owners commonly tried to initiate play using these physical signals.

In a study of the effects of a range of animals on kindergarten children, only dogs produced displays of intimacy through hugging and kissing (Nielsen and Delude 1989). A study of three-to-four year old children's interactions with dogs revealed that 67% of these interactions involved body contact with the dog, such as putting a hand on the dog, patting it or hitting it (Millot and Filiatre 1986). Alisdair Macdonald (1981) carried out a small questionnaire survey of children and their parents and their attitudes toward their pet dogs. Of the 32 children, there were thirteen cases where the dog slept in the child's room. Twenty six children were reported to play with the dog more than did any other family member, and seven frequently played using physical contact with the dog e.g. wrestling. The dog was exercised mainly by the child in twenty three cases.

In an additional larger study of facilitation of social contact by Messent (1983) the dog being walked was touched by a person other than the owner on 15% of walks; this might be considered a mode for disease transmission to other people met. Another interesting finding was that significantly more fetch games were observed with large dogs. This could have importance through transfer of saliva around the environment and to the hands of the owner.

1.5 Risk perception in dog ownership and contact with dogs

1.5.1 Dog bites

UK estimates suggest that 740 people per 100 000 population are bitten by dogs annually (Knott 2007). Most reviews suggest that larger dogs such as German shepherds, Pit Bull terriers and Rottweilers are the most likely to bite, but that all dogs should be considered potentially dangerous (Shewell and Nancarrow 1991). An accurate estimate of incidence is impossible, as dog bites are frequently unreported (Knott 2007). It is feasible that a bite from a Yorkshire Terrier or Border Collie would be less likely to be reported because they are not of breeds considered 'high profile' in terms of aggression, and are smaller so may cause less damage. Despite the risk of being bitten by a dog, many people still own them, including families with children. Therefore the risk must be considered to be small compared to the benefits of owning a dog. It has been quoted that "dogs bite, but a child is more likely to die choking on a marble or a balloon, and an adult is more likely to die in a bedroom slipper related accident than be killed by a dog; an individual's chances of being killed by a dog are roughly one in 18 million, one-fifth the probability of being killed by a bolt of lightning" (Bradley 2005). However, dog bites may cause physical and psychological damage even if they do not kill.

1.5.2 Zoonoses

Although there seems to be a considerable literature describing the risks of acquiring animal infections, the extent of the risk from owning a pet dog is currently unknown. It will be very difficult to quantify, especially as most cases of mild gastroenteritis, for example, are not reported anyway. It is generally thought that only a small proportion of infections in people can actually be attributed to pet contact (Greene and Levy 2006). Nonetheless, investigating the possible behaviours and management factors that may act as a means of infection transmission between dogs and humans is still important, as they do occur, as demonstrated in the studies discussed earlier.

It is generally accepted that dogs are more commonly present in families with children; however, it is also known that young children are at higher risk for zoonotic disease (Greene and Levy 2006). For all zoonoses, children suffer a higher risk because of their close physical contact with animals (Hart 1995a); examples of this were described above. When questioned on the potential problems of dog ownership, ten parents (of 32 children) stated concern over the danger of the child catching disease from the dog, far less than were concerned over the effects of eventual loss of the dog on the child (MacDonald 1981). The emotional and psychological benefits to having a dog seem to be considered a higher priority than risk of zoonoses or bites. In a survey of children grade 3-7 in California, seven factors in the child-pet relationship were identified by the children as areas of cost or distress (Bryant 1990a). These were: 1) distress of pet death and rejection, 2) distress associated with care, needs and nurturing of the pet, 3) unfair grief, 4) dissatisfaction or non-involvement with the pet's needs, 5) worry about pet safety, 6) getting into trouble and 7) distress of not being allowed to care for the pet's needs. Potential risk of disease was not included, either because it did not prove significant to publish or the questionnaire designers did not think it important to discuss this topic with the children in the first place.

In addition to children, other groups in human society are also at greater risk for zoonotic infection, for example the elderly, pregnant women and the immunocompromised (Robinson and Pugh 2002). As medical care has improved, zoonoses have become a more important threat, as the proportion of immunocompromised individuals have increased through organ transplants, cancer treatments or treatment of long-term disease such as diabetes (Wong and others 1999). If an immunodeficient immune system means a higher risk of infection with zoonoses then care should be taken around pets. The most common infections acquired by immunocompromised persons from pets are those caused by *Salmonella* and *Campylobacter* spp (Glaser and others 1994).

It has been suggested that although 30-40% of immunocompromised people may own pets (Wise and Yang 1992) few individuals are offered information about zoonosis prevention; if they are, physicians may ask that they give up the pets altogether, despite the benefits from owning a pet (Angulo and others 1994). The veterinarian is proposed as an alternative source of information and monitoring of the animals. Recommendations suggested for the pets include: closely supervised at all times; not having access to garbage or toilet bowls; not being allowed to hunt, scavenge or eat other animals' faeces; and being given bottled drinking water if the tap water is not fit for human consumption. Also, the persons should wash their hands after handling pets, especially before eating, and avoid pet faeces. When obtaining a new pet, zoonotic disease risk should also be considered. Angulo and others (1994) noted that the hygiene and sanitary conditions in pet stores, breeders and rescue kennels can vary, and young animals, especially with diarrhoea, should be avoided, as they are more likely to be shedding *Salmonella*, *Campylobacter*, *Cryptosporidium* or *Gardia* spp. Although these guidelines have been written with regard to immunocompromised people, they could also apply equally to the general dog owning population.

1.5.3 Perception of risk

Despite the risks associated with dog ownership they remain popular pets. It has been shown that people seem able to tolerate higher risk from activities that seem highly beneficial (Slovic 2004), so it may be that the perception of costs from dog ownership in society is outweighed by the benefits. Amongst other characteristics, level of knowledge also seems to influence the relationship between perceived risk, perceived benefit and risk acceptance (Slovic 2004). It is possible that the general dog owner has limited knowledge on the potential disease risks associated with dog ownership in the UK. Heller and others (2007) reported from a small questionnaire survey in towns in Scotland, that the proportion of respondents that recognised different zoonotic diseases listed was variable. Correct identification of a pathogen as being zoonotic ranged from 30.2% (MRSA) to 63.9% (Tapeworm).

The problem of dog bites is more extensively covered by the media than zoonoses, and relinquishment to shelters may considerably increase when the media have been reporting dog bites and dangerous dogs, possibly as a consequence (BBC 2007). Rabies is not endemic in the UK (DEFRA 2006), and so dogs may be perceived as less of a problem than in other countries where rabies is endemic. However dog ownership is still high in countries where rabies is present such as the USA (Anon 2004a), and so perceived benefits must be counteracting the perceived risk. 'Affect' can also affect perceived risk: if an activity is 'liked', people tend to judge its benefits as high and its risks as low; if an activity is 'disliked' the judgements are opposite – low benefit and high risk (Alhakami and Slovic 1994). Therefore it is feasible to suggest that people who like spending time with or owning dogs, consider that the risks of dogs in society are smaller than those who do not like dogs.

1.6 Dog-dog interactions

Pet dogs have a social network with other dogs that they meet, most probably on walks. The size of this network could depend on both the individual behaviour of the dogs (such as whether they greet other dogs or ignore them) and the management of the dogs by their owners (such as where they walk them, how often, and whether the dog is kept on a lead). A group of dogs that regularly walk together in the same area and interact a lot with each other may constitute a large number of closely linked individuals, but if these dogs only ever interact with dogs in the group, there could also be a protective effect on the group from infections in the larger network. Studies in humans have shown that, for sexually transmitted infections, a person's risk for infection is determined by local rather than global network structures, and that as components (groups within the network) increase in size, establishment of infection becomes more likely (Ghani and others 1997).

Owners who like to drive their dogs to another area to walk may increase the distance over which the network spans. Similarly attendance at training classes, grooming parlours and veterinary surgeries are opportunities for dogs from a wide area to meet, and in the case of veterinary surgeries the dogs are also more likely to have an infectious disease. Some people take their dogs hundreds of miles on holiday with them or to compete in shows.

Whilst walking, a dog may perform behaviours by which it comes into physical contact with other dogs and people. These direct interactions could provide modes of pathogen transmission between dogs, for both zoonotic and non-zoonotic infections. Pathogens may also be transmitted indirectly for example during sniffing of excretions. The disease transmission potential is likely to be variable between dogs depending on their individual behaviour preferences, and due to other factors for example: type of walking area, owner behaviour, use of the lead, and weather.

In a study limited to two sites (forest and urban common) in Hampshire, UK, it was observed that on lead dogs were never the initiator of interactions with another dog and the subsequent interaction was terminated by either the dog (76%), the person holding the lead (13%), or it was ambiguous who terminated it (11%) (Bradshaw and Lea 1992).

Interactions when one dog was on lead were also seen to be shorter in length than if both were off-lead, when chase games could develop. When two dogs met the most common interactions seen were inspection of the head and anogenital areas, with males investigating the anogenital area much more frequently than females. Therefore sex of the dogs (and possibly neuter status) affects the type of interactions. Investigation of the anogenital area was more frequent at the forest site, where dogs were less likely to have encountered each other previously than at the common, suggesting that the choice of walking area can affect the nature of dog-dog interactions.

As described, previous studies have investigated the walking activity and behaviour of individual dogs, but they have not considered the networks of contacts that arise through this, or the frequency of dog-dog interactions. Social network analysis has been used in order to investigate a number of other species, including humans, for areas of potential contact between individuals in relation to infectious disease transmission (for example, Christley and French 2003; Corner and others 2003; Klovdahl and others 1994; Robinson and Christley 2007; Robinson and others 2007). This approach has been found useful for investigating the epidemiology of sexually transmitted infections in a population of prostitutes, injecting drug users and their associates in Colorado Springs (Klovdahl and others 1994). Network analysis has also been used to identify predictive variables of *Mycobacterium bovis* transmission via den sharing in captive brushtail possums (Corner and others 2003) and in particular to evaluate livestock movement data in respect to diseases such as foot and mouth (Kao and others 2006; Robinson and Christley 2007; Robinson and others 2007). So far, little is known about the structure of social networks in pet dogs, but it could have important implications for disease transmission, depending on the frequency and types of interactions.

1.7 Objectives of the Thesis

The studies presented in this thesis aim to investigate the characteristics of pet dogs in a small community in the UK, concentrating on dog ownership, the social behaviour of dogs and their owners, and the resultant social networks. Throughout the thesis, consideration is given to the potential for transmission of pathogens between dogs and between dogs and humans, in addition to the investigation of the behaviours themselves. To do this, a number of studies and methodologies have been undertaken in order to attempt to quantify the interactions that occur and evaluate their possible role in disease transmission. Such information may then be used to target intervention strategies and preventive measures.

Chapter Two investigates who owns dogs using a cross-sectional door-step interview survey of a community of 1278 households. It also describes the general contact with dogs that individuals from these households reported.

Chapter Three presents a descriptive cross-sectional questionnaire study of 327 dogs belonging to 260 households in the same community. This includes: dog demographic information, sleeping areas, playing behaviours, greeting behaviours, food sources, walking, disposal of faeces, veterinary preventive treatment and general hygiene.

Chapter Four uses Social Network Analysis to construct networks of dog owning households and walking areas and describe associated network characteristics and implications for disease transmission.

Chapter Five reports a risk factor analysis for *Campylobacter upsaliensis* carriage, an exemplar of a potential zoonotic pathogen, diagnosed by culture and PCR (Polymerase Chain Reaction) from faeces collected from 183 dogs from the community study in Chapter Three.

Chapter Six is a focal-animal observation study of dogs being walked in three areas, both on and off lead as observed. It describes the frequencies and durations of contacts with other dogs, other people, and other behaviours such as sniffing, defaecating and urinating.

Chapter Seven uses an experimental approach to further examine the effect of lead use on interaction with people and interactions with dogs, through a study of ten dogs observed walking both on and off lead.

Chapter Eight reviews the information gained from these studies and discusses practical applications of the concepts.

CHAPTER TWO

FACTORS ASSOCIATED WITH DOG OWNERSHIP AND CONTACT WITH DOGS IN A UK COMMUNITY

This Chapter has been published as a paper:
Westgarth, C., Pinchbeck, G. L., Bradshaw, J. W. S., Dawson, S., Gaskell, R. M. & Christley, R. M. (2007) Factors associated with dog ownership and contact with dogs in a UK community. BMC Veterinary Research 3, 5.

ABSTRACT

Dogs are popular pets in many countries. Identifying differences between those who own dogs or have contact with dogs, and those who do not, is useful to those interested in the human-animal bond, human health and provision of veterinary services. This census-based, epidemiological study aimed to investigate factors associated with dog ownership and contact with dogs, in a semi-rural community of 1278 households in Cheshire, UK.

Twenty-four percent of households were identified as dog owning and 52% owned a pet of some type. Multivariable logistic regression suggested that households were more likely to own a dog if they had more occupants (5 or more); if they had an adult female household member; or if they owned a horse. The age structure of the households was also associated with dog ownership, with households containing older children/young adults (6-19yr olds or 20-29yr olds) more likely to own dogs. We also found that dog owning households were more likely to be multi-dog households than single-dog if they also owned a cat or a bird, or if the household contained a person of 20-29 years old. Dog owners reported increased general contact with dogs, other than their own, compared to those that did not own dogs and this contact appeared to be mainly through walking.

Some household types are more likely to own a dog than others. This study supports the suggestion that dogs are more common in families who have older children (6-19 years), as has been generally observed in other countries. Dog owners are also more likely to have contact with dogs other than their own, compared with those not owning a dog.

2.1 INTRODUCTION

Humans and dogs have lived in close proximity for thousands of years. The effect of pet ownership on human health has been studied on a number of occasions but has been somewhat inconclusive due to the difficulties in studying such a complex relationship and assigning direction of causation (Headey 2003). Pets provide companionship and also probably confer physiological health and psychological benefits (Friedmann 1995; Headey 2003; Katcher 1981; Katcher and Friedmann 1982; McNicholas and others

2005). For example, pet owners have fewer visits to doctors (Heady and others 2002) and longer survival following heart attack (Friedmann and others 1980), compared to non-pet owners. Katcher and Friedmann (1982) suggested seven common functions of pet ownership: companionship; something to care for; something to touch and fondle; something to keep one busy; a focus of attention; exercise and safety. Pets have also been indicated to have important roles in enhancing child development (Brodie 1981; Endenburg and Baarda 1995; Katcher and Friedmann 1982), the well-being of older people (Brodie 1981; Hart 1995b; Katcher and Friedmann 1982) and may also be used in a therapeutic setting (Burch and others 1995; Endenburg and Baarda 1995; Hart 1995b).

Dogs and cats are the most popular pets in the UK, although dog ownership has declined slightly over recent years (PFMA 2004). In 2004 there were approximately 5.2 million dog owning households in the UK (21% of households), owning 6.8 million dogs (PFMA 2004). The demographics of pet ownership are of health, psychological and social science interest, applicable to the research area of the nature of the pet-human bond and can also be used to inform provision of veterinary services.

It has become apparent that pets may be an important source of zoonotic infections. Approximately 30 to 40 organisms that cause zoonotic infections are known in companion animals, including dogs (Greene and Levy 2006). Some groups in human society are at greater risk of zoonotic infection due to their immune system or behaviour; for example, young children, the elderly, pregnant women and the immunocompromised (Greene and Levy 2006; Robinson and Pugh 2002). Virtually everyone in the community is in contact with either companion animals or their products, including excreta (Egerton 1982).

Previous epidemiological studies in the USA and Australia have suggested that pets are more common in families who have children (Beck and Meyers 1996; Franti and Kraus 1974; Franti and others 1980; Leslie and others 1994; McHarg and others 1995; Messent 1984; Teclaw and others 1992; Tower and Nokota 2006; Troutman 1988; Wise and Kushman 1984; Wise and Yang 1992). In contrast, a study of dog ownership in Germany found that the majority of the dog owners did not live with children younger than 18 years of age (Brand 2002); however this study was conducted in a big city

(Berlin) and recruited via dog training schools and vets, and therefore was likely biased towards professional-type people, who had sufficient time and money to own a dog in a large city and take it to training classes, and may be less likely to have children.

This project aimed to investigate factors associated with dog ownership in a semi-rural community using a doorstep interview questionnaire. The previous studies mentioned used telephone interview or mail questionnaire methods to sample a small proportion of a large study population. In contrast, this study attempted to doorstep interview all households in a defined geographic area to produce a detailed census of a single community. Whereas some other studies have combined dogs and cats as 'pets' for analysis, this study focused specifically on dogs; reasons for dog versus cat ownership are likely to differ as they have different ownership requirements.

2.2 METHODS

2.2.1 Survey methods

A community of 1278 houses in Cheshire, UK, was identified as the study area. This area is on the edge of a town and was selected because it is reasonably well defined by natural boundaries, has a mixture of medium and low-density housing, has public amenities including parks, and is near to sports fields, a wildlife reserve and agricultural land. In the 2001 census data it contained a lower percentage of unemployed people than the national average and slightly more managerial and professional type occupations (Office for National Statistics 2001b). The sample was selected as it was a contained area in order to gather appropriate and sufficient network data for Chapter 4. Data were gathered using a questionnaire containing multiple choice and open-ended questions, administered during face-to-face doorstep interviews. The questionnaire had been thoroughly pre-tested, revised and piloted on approximately 100 households in a nearby area. It was designed using a high-accuracy, high-throughput automated content capture system, TELE*form* v9.1 (Verity Software, 2005), aiding design in a professional format and facilitating rapid and accurate data entry. Please refer to General Appendix for questionnaire.

Each household was identified by address and visited up to five times over a five week period (July-August 2005). The time of visiting each house varied between 2pm-8pm weekdays and 10am-5pm Saturdays in an attempt to increase the possibility of interview, as identified in a pilot study. All households were sent an informational leaflet a week prior to commencement of the interviews, although zoonoses were not mentioned to avoid potential bias. Willing persons over 16yrs of age were interviewed on the door-step by trained interviewers following consistent procedures to minimise interviewer bias. They were asked about their pets, possible reasons for not owning a dog, contact with dogs and household demographics. This included for each individual household member: gender, age category and job description or other reasons for not being in employment. Job descriptions were later categorised into general types based on Standard Occupational Classification 2000 (SOC 2000), if enough information was available. Interviewees could terminate the interview at any time or not disclose certain information if they wished and they were assured that the information would remain confidential. The interview took approximately two minutes.

2.2.2 Data analysis

Data were managed in a Microsoft Access Database and analysed using Microsoft Excel (Microsoft Corporation, 2003), Minitab (Minitab release 14.2, Minitab Inc, 2005) and SPSS (SPSS 13.0 for Windows, SPSS Inc, 2004). Dog-owning (DO) and dog-free (DF) household responses to each question were initially compared using chi-squared analysis, Fisher's exact test and univariable logistic regression. Similar methods were used to compare single with multiple dog households. When considering data collected at the level of the individual household member, the analysis was done at the household level considering presence or absence of each category.

Development of a multivariable model of dog ownership was complex due to correlation between many of the demographic variables measured at the level of the household member (age and occupation), rather than the household level (at which the outcome was measured). Because of this, hierarchical cluster analysis was used to classify households into categories by age distribution and separately into occupation categories (excluding full-time students, unemployed, looking after home/family, or permanently sick/disabled), using the Ward method for distance measurement and based on presence or absence of appropriate categories. This was an iterative process until satisfactory division of clusters was reached that approximated some real-life meaning. The age (n=6) and occupation (n=9) distribution cluster groupings were used to build a multivariable model of dog ownership. Due to correlation between household age category 1 (Over 60s) and household occupation category 4 (retired), households in either of these categories were initially excluded from development of the multivariable model using backward elimination. The final model was then applied to the full set of data. Variables and interaction terms remained in the model if they were significant in the model (P<0.05) or if removal resulted in substantial change to the effect of other variables (10% or greater). The fit of the model was assessed using the Hosmer-Lemeshow statistic.

2.3 RESULTS

2.3.1 Response rates

A total of 1142 households (89% of all council registered households in the study area) were contacted within five visits to the property. A further 136 households (11%) could not be contacted during five attempts, although 2% of the total properties were suspected to be unoccupied and another 2% were removed from the survey for reasons including occupants being too elderly, identified by neighbours. Over half (53%) of the households were interviewed during the first round of visits (Fig.2.1). Of those households contacted and asked to participate, 1051 (92%) were fully interviewed, 24 (2%) part-interviewed (answered some but not all questions) and 67 (6%) were not willing to participate in the study (see Fig.2.2 for summary of all households in study area). This gave an overall usable response rate of 84%.

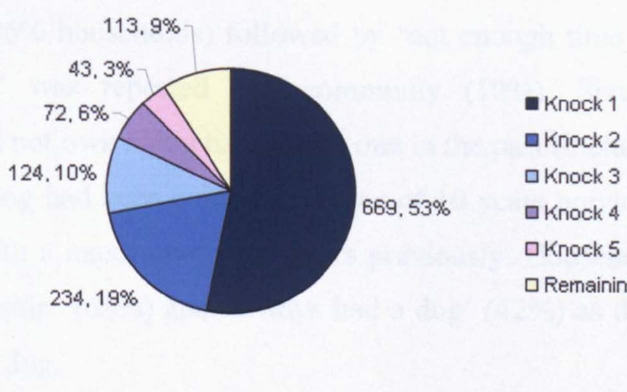


Figure 2.1 Percentage of households contacted in each visit (knock) (N=1255).

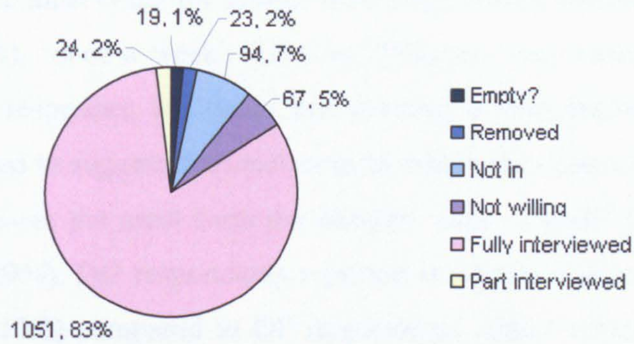


Figure 2.2 Outcome of all 1278 households surveyed.

2.3.2 Pet ownership

A summary of the responses to each individual question is given in the General Appendix at the end of this thesis. Of the households contacted, 24% (266) were identified as dog owning (DO); only 4 of these DO households were not willing to be interviewed. There was no significant difference between the response (willing or not willing to participate) of DO and DF households ($P>0.1$). Two hundred and one (77%) DO households owned one dog, 53 (20%) two dogs and 8 (3%) three dogs (mean 1.3 dogs). Just over half (53%) of all interviewed households owned a pet of some type. A variety of other pets were identified, cats (22% of households) being the most popular after dogs.

2.3.3 Reasons for and against owning a dog

The most common reason given for not owning a dog by DF was due to 'working or being out all day' (26% households) followed by 'not enough time for a dog' (15%). 'Do not like dogs' was reported less commonly (10%). Sixty-two percent of interviewees who did not own a dog had owned one in the past (including as a child). In such cases, the last dog had been owned a median of 10 years previously (interquartile range 5-24 years) with a maximum of 80 years previously. Households owning a dog reported 'companionship' (68%) and 'always had a dog' (42%) as their most common reasons for owning a dog.

2.3.4 General contact with dogs

When asked how often they came into physical contact with dogs (other than their own) DO reported increased contact compared to DF ($P<0.001$); 'everyday' (DO vs DF; 49%

vs 14%) was clearly the most common answer from dog owners, whereas 'several times a week' (23% vs 21%), 'once a week' (12% vs 20%), or 'very rarely' (8% vs 23%) were more common responses for those not owning a dog themselves (Fig.2.3). Interviewees were asked to suggest circumstances in which they come into contact with dogs other than their own; the most common answers were 'friends' (32%), 'walking' (31%) and 'family' (29%). DO respondents reported increased contact whilst walking (OR=7.4, 95%CI 5.4-10.0) compared to DF respondents. Other associations with dog ownership were decreased contact with dogs through neighbours and increased contact through employment (OR=0.6, 95%CI 0.4-1.0 and OR=1.8, 95%CI 1.1-2.9 respectively).

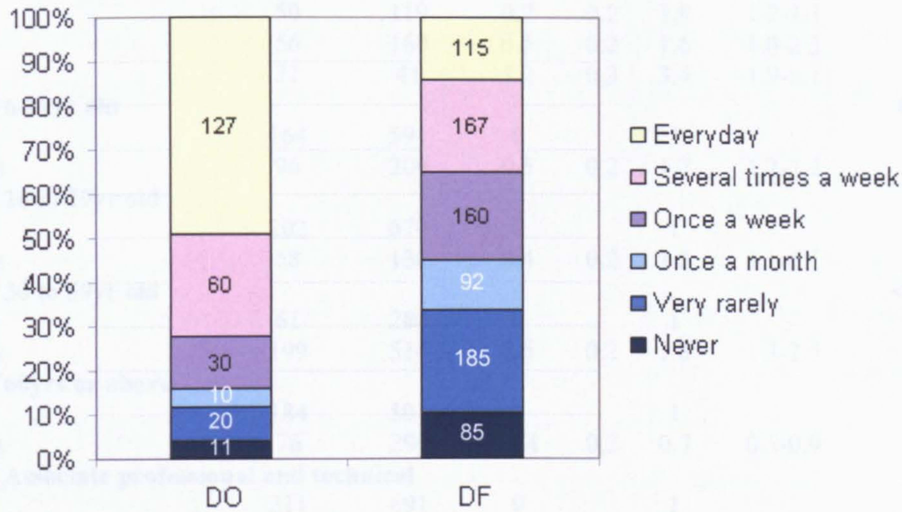


Figure 2.3 Reported contact with dogs (other than own dog) for Dog-owning (DO) and Dog-free (DF) households .
The numbers indicate the number of respondents in each category. DO households were significantly more likely to have more frequent contact with dogs, compared to DF households (P<0.001).

2.3.5 Univariable analysis

Univariable analysis of DO versus DF (Table 2.1) identified presence of birds, fish and horse as significantly positively associated with DO status (P<0.05). There was no evidence of an association between cat ownership and owning a dog.

Table 2.1 Significant findings (P<0.05) on univariable analysis of factors associated with dog ownership in a community in Cheshire, UK.
For tables including non-significant variables please see Appendix to Chapter Two, Tables 1-8.
DO=dog-owning, DF=dog-free, Coef=coefficient, SE=standard error, OR=odds ratio, 95%CI=95% confidence intervals, P-value = Pearson's Chi-Square, or * Fisher's exact test P-value.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Birds							**0.02**
No	246	788	0		1		
Yes	16	24	0.8	0.3	2.1	1.1-4.1	
Fish							**0.02**
No	220	725	0		1		
Yes	42	87	0.5	0.2	1.6	1.1-2.4	
Horse							**<0.01***
No	253	807	0		1		
Yes	9	5	1.7	0.6	5.7	1.9-17.3	
N^o People							**<0.001**
1	39	177	0		1		
2	85	303	0.2	0.2	1.3	0.8-1.9	
3	50	119	0.7	0.2	1.9	1.2-3.1	
4	56	160	0.5	0.2	1.6	1.0-2.5	
5+	31	41	1.2	0.3	3.4	1.9-6.1	
Presence of 6-19yr old							**0.001**
No	164	591	0		1		
Yes	96	209	0.5	0.2	1.7	1.2-2.2	
Presence of 20 to 29yr old							**0.03**
No	202	670	0		1		
Yes	58	130	0.4	0.2	1.5	1.1-2.1	
Presence of 30 to 59yr old							**<0.001**
No	61	286	0		1		
Yes	199	514	0.6	0.2	1.8	1.3-2.5	
Presence of 60yrs or above							**0.02**
No	184	501	0		1		
Yes	76	299	-0.4	0.2	0.7	0.5-0.9	
Presence of Associate professional and technical							**0.04**
No	211	691	0		1		
Yes	49	109	0.4	0.2	1.5	1.0-2.1	
Presence of Skilled trade							**0.001**
No	200	688	0		1		
Yes	60	112	0.6	0.2	1.8	1.3-2.6	
Presence of Personal service							**<0.001**
No	228	755	0		1		
Yes	32	45	0.9	0.2	2.4	1.5-3.8	
Presence of Unemployed							**0.004***
No	252	795	0		1		
Yes	8	5	1.6	0.6	5.1	1.6-15.6	
Presence of Retired							**0.002**
No	193	511	0		1		
Yes	67	289	-0.5	0.2	0.6	0.5-0.8	
Presence of Full-time student							**0.01**
No	163	570	0		1		
Yes	97	230	0.4	0.2	1.5	1.1-2.0	
Presence of adult female							**0.004**
No	12	84	0		1		
Yes	245	700	0.9	0.3	2.5	1.3-4.6	
Adult gender household							**0.01**
All male	12	84	0		1		
All female	40	144	0.7	0.4	1.9	1.0-3.9	
Mixed male/female	205	554	1.0	0.3	2.6	1.4-4.8	

There was no evidence for a significant effect of either house type (flat, terrace, semi-detached and detached) or street type (cul-de-sac, through road) on household ownership of dogs (P=0.6 and P=0.9 respectively) in this area. The percentage of DO households in each street varied widely from 0 to 60%. There were insufficient numbers of households with no garden or only a yard to compare with those with a garden. There was no evidence for a significant difference between DO and DF with respect to the amount that the garden was used for recreational purposes (such as eating, gardening, children playing) (P=0.98). 'Often' was the most common response (74%), likely due to the study being conducted during summer months.

Two person households were most common in this population (37%). DO households were associated with greater numbers of people living in them (Table 2.1). The median number of persons per household was 2 for DF and 3 for DO, both with interquartile ranges 2-4. Mixed adult gender households were more likely to own a dog than single gender households (Table 2.1). However this variable was associated with the number of people in the household (P<0.001), with larger households more likely to have mixed genders and 1-2 person households more likely to be adult male or adult female only. Not surprisingly, increasing numbers of adult males and/or females were also associated with presence of a dog. Consequently, these variables was not used in multivariable analysis and presence/absence of an adult female and presence/absence of an adult male was preferred as an indicator of gender structure of the household. When considering presence of adults in the household, presence of an adult female was significantly associated with dog ownership (Table 2.1).

DO and DF households were compared for presence and absence of particular age categories (Table 2.1). Presence of the age groups 6-15yrs, 16-19yrs, 20-29yrs and 30-59yrs increased the odds of owning a dog. If categories were combined, households with a 6-19yr old, or under19yr old were also more likely to own a dog, and households where a person of 60yrs or older was present were less likely to own a dog. Again, the variable type presence/absence of an age group was chosen for use for modelling as numbers of people in an age group is related to numbers of household members. Certain occupations also influenced dog ownership (Table 2.1). The presence of Associate professionals, Skilled trades and Personal service occupations were each positively associated with dog ownership. Presence of Unemployed, Permanently sick/disabled persons or Full-time students (including children of school age) in the household also increased the odds of dog ownership. Households with a retired person were less likely to own a dog.

Univariable analysis was also conducted on the dog owning households to compare single-dog households with multiple-dog households (Table 10 in Appendix to Chapter Two). Significant findings that increased the odds of being a multi-dog household compared to single included presence of a cat or bird (OR=2.3, 95%CI 1.1-4.5 and OR=4.8, 95%CI 1.7-13.5 respectively), or presence of at least one 20-29yr old person (OR=2.07, 95%CI 1.1-3.9).

2.3.6 Hierarchical cluster analysis of age and occupation

The external validity of groups identified by cluster analysis can be assessed by comparing the results of the cluster analysis with an external criterion (Sharma 1996). The age groups and occupation groups identified using hierarchical cluster analysis (summarised in Table 2.2) were both significantly associated with dog ownership in univariable analysis ($P \leq 0.001$, Table 2.3). These household age and occupation cluster groups were used in the multivariable modelling of dog ownership instead of individual variables for each age and occupation.

2.2 Description of groups from hierarchical cluster analysis of age and occupations.

Household age categories ($\chi2$ P=0.001)	**Description of households**
1 (Over 60s)	Persons over 60yrs present in all households, size mainly 1-2 persons.
2 (Families)	Very few households with under 5yrs present, some with 6-19yrs, many with 20-29yrs, many with 30-59yrs, size 1-5 persons.
3 (Families)	6-19 yrs present in all, 30-59yrs in all, size 2-5 persons.
4 (Singles/couples adults)	30-59yrs present in all households, size 1-4 persons (mostly 1-2).
5 (Young families)	Under 5yrs present in all households, many 6-19yrs, few 20-29yrs, many 30-59yrs, very few 60+yrs, size mainly 3-5 persons.
6 (Older families)	Very few households with 6-19yrs present, few 20-29yrs, many 30-59yrs, all households 60+yrs present, size mainly 2-4 persons.
Household occupation categories ($\chi2$ P<0.001)	**Description of households**
1 Sales	Sales occupation present in all households, other occupations mainly professionals, associate professionals, admin, process/plant, retired persons.
2 Skilled trade	Skilled trade occupation present in all households, other occupations mainly managers, professionals, sales persons.
3 Administrative and secretarial	Admin occupation present in all households, other occupations mainly managers, associate professionals, skilled, retired persons.
4 Retired	Retired occupation present in all households, no other occupations present.
5 Personal service	Personal service occupation present in all households, other occupations mainly managers, associate professionals, admin, skilled trades, sales, process/plant and retired persons.
6 Associate professionals	Associate professional occupation present in all households, other occupations mainly managers, professionals, skilled trade persons.
7 Process/plant and elementary.	Process plant and elementary occupation present, other occupations mainly associate professionals, admin, skilled trade persons.
8 Professional	Professional occupation present in all households, also other occupations mainly admin and retired persons.
9 Managers and senior officials	Manager occupation present in all households, other occupations mainly professional persons.

Key to occupations: Manager and senior officials (managers), Professional occupations (professionals), Associate professional and technical occupations (associate professionals), Administrative and secretarial occupations (admin), Skilled trades occupations (skilled), Personal service occupations (personal service), Sales and customer service occupations (sales), Process, plant and machine operatives (process/plant), Elementary occupations (elementary).

Table 2.3 Univariable analysis of age and occupation cluster analysis groups.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Age group							**0.001**
5 (Young families)	17	79	0		1		
1 (Over 60s)	51	238	-0.0	0.3	1.0	0.5-1.8	
2 (Families)	51	115	0.7	0.3	2.1	1.1-3.8	
3 (Families)	68	146	0.8	0.3	2.2	1.2-3.9	
4 (Singles/couples adults)	49	160	0.4	0.3	1.4	0.8-2.6	
6 (Older families)	24	60	0.6	0.4	1.9	0.9-3.8	
Occupation group							**<0.001**
5 All personal service	32	44	0		1		
1 All sales	15	48	-0.8	0.4	0.4	0.2-0.9	
2 All skilled trade	28	72	-0.6	0.3	0.5	0.3-1.0	
3 All admin	31	84	-0.7	0.3	0.5	0.3-0.9	
4 All retired	48	240	-1.3	0.3	0.3	0.2-0.5	
6 All associate professionals	35	70	-0.4	0.3	0.7	0.4-1.3	
7 Process/plant and elementary.	33	108	-0.9	0.3	0.4	0.2-0.8	
8 All professional	20	74	-1.0	0.3	0.4	0.2-0.7	
9 All managers	18	58	-0.9	0.4	0.4	0.2-0.9	

2.3.7 Multivariable analysis

Due to correlation between age group 1 (over 60s) and occupation group 4 (retired) (88% of households in age group 1 were also in occupation group 4), households in either of these categories were initially excluded from development of the multivariable model (Table 10 in Appendix to Chapter Two). This reduced the correlation between age groups and occupation groups from (Pearson correlation) 0.15 to 0.02. This model was then examined using the full data set as the final model (Table 2.4). The effects of the two models were very similar and therefore only the final model has been presented here (the initial model is presented in Appendix to Chapter Two). None of the correlations between variables used in the final model were high (all <0.4). In the final model, ownership of a horse, age groups, number of persons in the household, and presence of adult females were associated with the presence of one or more dogs in the household. The model appeared to fit the data well (Hosmer-Lemeshow statistic = 0.9). There were no significant two-way interactions between variables in the final model. Thirty-one (3%) households were not included in the final model due to missing data.

Table 2.4 Multivariable logistic regression model of factors associated with dog ownership in a community in Cheshire (n=1044). Hosmer-Lemeshow statistic P-value =0.9.

Variable	Coef	SE	OR	95% CI	P-value
Horse					**0.01**
No	0		1		
Yes	1.6	0.6	5.1	1.7-15.5	
Number of persons					**0.06**
1	0		1		
2	-0.1	0.3	0.9	0.5-1.5	
3	0.3	0.4	1.3	0.6-2.8	
4	0.1	0.4	1.1	0.5-2.4	
5+	10.9	0.4	2.4	1.0-5.7	
Age group (from cluster analysis)					**0.04**
5 Young families	0		1		
1 Over 60's	0.4	0.4	1.5	0.7-3.5	
2 Families	0.8	0.3	2.3	1.2-4.3	
3 Families	0.8	0.3	2.2	1.2-4.0	
4 Singles/couples adults	0.8	0.4	2.3	1.0-5.2	
6 Older families	0.9	0.4	2.5	1.1-5.5	
Presence of adult female					**0.03**
No	0		1		
Yes	0.8	0.4	2.2	1.1-4.6	

2.4 DISCUSSION

2.4.1 Comparison with other pet ownership estimates

This study on dog ownership and contact with dogs focused on a small geographic area and the results cannot necessarily be generalised to other parts of the UK or other countries. However, the percentage of the population owning a pet was almost identical to the 53% reported previously for the UK in 2004 (PFMA 2004), and the results gained from this study may be at least indicative of similar communities in the UK. Dog ownership was slightly higher (24% compared to 21%), and cat ownership lower (21% compared to 25%) in the current study compared to UK estimates, which may have been due to the semi-rural location being suitable for dog ownership. In a previous American postal questionnaire study mailed to 40,000 US households (Troutman 1988), the mean number of dogs owned by dog owning households was 1.5 compared to 1.3 found here, possibly reflecting the general increased level of dog ownership in America compared to the UK (38% households versus 21-24%) and the decreasing trends for dog ownership in recent years in the UK (PFMA 2004). It is unknown how the households in the study by Troutman were selected and whether it was a random sample, as it was only described as a 'representative sample'. Comparing to Australia, a study of a randomly selected group of dog owners in Perth interviewed by telephone questionnaire estimated 1.2 dogs per household, similar to our findings, but again a higher percentage of all households approached were identified as owning a pet (56%) or a dog (31%) (Robertson and others 1991).

This study attempted to survey all households in a defined geographic area, and the results will be biased due to the type of area (part of a small rural town) used. However, the sampling methods used in other studies, such as recruiting from veterinary, insured, internet-using, telephone-owning or pro-/anti-dog populations, may have introduced bias not apparent in our census-based study method. It could be hypothesised that dog owners might be more willing to participate in the survey because it is of more interest to them. However here was no significant difference between the response (willing or not willing to participate) of DO and DF households. Previous information introducing the study (leaflets), combined with the local knowledge of and community links with the local veterinary teaching hospital, may have contributed to the very good response rate for the interviews, but also may have influenced answers such as expressing the true reasons for not wanting to own a dog. Bias may have been introduced into the study by the choice to interview the person who answered the door, as reasons for not owning a dog, or contact rates, may differ between household members. However, this method likely contributed to the high interview rate, as stipulating to speak to the 'head of the household' or similar methods would have reduced the success rate if they were not available for interview at that time.

2.4.2 Summary of the risk factors identified

Univariable analysis identified a number of variables potentially associated with dog ownership including: ownership of other animals (fish, birds, horse); the presence of older children (school age); an increased number of persons in the household; Associate professional, Skilled trades and Personal service occupations, Unemployed, Permanently sick/disabled, Full-time students; and adult females. In contrast, over 60s or retired persons had lower odds of owning a dog on univariable analysis, possibly explained by reduced mobility, or not replacing a deceased pet because of a new pet's perceived longevity, however this finding was not significant after accounting for other variables during multivariable analysis. On multivariable analysis, ownership of a horse, age distribution and number of persons in the household and presence of adult females were found to be the most important factors. Ownership of fish and birds did not remain in the final model. Possibly the commitment in regards to time, care and expenses given by horse owners to their horse(s) complement the required lifestyle when owning a dog. This finding has not been reported previously but may be due to the semi-rural nature of the study area.

2.4.3 Families and children

This study supports the common suggestion that pets, in this case dogs, are more common in families who have children (Beck and Meyers 1996; Franti and Kraus 1974; Franti and others 1980; Leslie and others 1994; McHarg and others 1995; Messent 1984; Teclaw and others 1992; Tower and Nokota 2006; Troutman 1988; Wise and Kushman 1984; Wise and Yang 1992). However, this effect may be modified by the age of the children, which was not always investigated sufficiently in other studies. In our multivariable model, families with young children (in this case 5 years and under) were significantly less likely to own dogs, and similar findings have been reported by others (Leslie and others 1994; Wise and Kushman 1984). In contrast, Teclaw and others (1992) concluded (but on the basis of univariable analysis only) that there was no significant effect of young children in the household on pet ownership. Amongst young children, dog ownership is a risk factor for zoonotic disease, for example campylobacteriosis (Tenkate and Stafford 2001), however reduced dog ownership by families with young children may lessen this effect.

Several theories have been proposed to account for potential interactions between pet ownership and the presence of children in a household (Feldmann 1997; Katcher 1981; Leslie and others 1994). Our finding that dogs are often owned by households with older children could be explained if children in the older age groups had encouraged their parents to acquire a dog, and/or the parents felt that that ownership would benefit the children (Leslie and others 1994). Alternatively, some parents may have acquired dogs as surrogate dependents as their children grew up and became less receptive to physical contact and being fussed over (Katcher 1981).

2.4.4 Housing type

In our study there was no significant effect of housing type, whereas previous work has suggested that pet owners are more likely to live in single-family dwellings and larger houses (Franti and Kraus 1974; Franti and others 1980). Such differences between studies may reflect real differences in the study population, or may be due to the fact that we were considering only dog ownership compared to general pet ownership, and/or insufficient power to detect a difference in a small and relatively homogeneous study area.

2.4.5 Occupation and income

Variations in pet ownership with annual household income level (Franti and Kraus 1974; Franti and others 1980; Leslie and others 1994; Teclaw and others 1992; Troutman 1988; Wise and Kushman 1984; Wise and Yang 1992) are possibly comparable to the variations in occupations found on univariable analysis in this study. Dog ownership was associated with higher household incomes in some American studies (Franti and Kraus 1974; Franti and others 1980; Teclaw and others 1992; Troutman 1988; Wise and Yang 1992). However, the occupations indicated by our findings as being associated with dog ownership (Associate professional and technical, Skilled trade and Personal service) are not ones that would necessarily be expected to receive high incomes (for example Managers and senior officials), but this effect may be specific to the location of our study. The role of occupation or income in dog ownership is likely to be intertwined with other factors and may be not as important as seems; this is supported by the fact that it was not significant in our final multivariable model. Similarly in another American study, stratification by household characteristics and life groups (similar to our age cluster groupings) appeared to account for the effects of education and household income on dog ownership (Wise and Kushman 1984). A study in Ontario also concluded that socioeconomic status was not unconditionally associated with pet ownership after multivariable analysis (Leslie and others 1994).

2.4.6 Gender differences

The finding that presence of an adult female in the household was associated with dog ownership may be due to differing attitudes to pets between the sexes. Tower and Nakota (2006) investigated the relationships between depression and pet ownership (dogs and cats) in the USA using an internet survey. They found that for men: being married, living with children, being Midwestern and non-urban increased odds of living with a pet, and for women: being white, having a high income, living with children and living in a rural setting increased odds of pet ownership. They concluded that unmarried women living with a pet had the lowest depressive symptoms and unmarried men living with a pet the highest, leading them to suggest that single men may be burdened by pet ownership, whereas single women may benefit from pet companionship, but when married the pet may bring additional stress to the woman already possibly nurturing a family. Our study supports the suggestion that there are underlying differences between the sexes with regard to pet ownership, but internet questionnaire studies like the one described above may be biased in their sampling method due to limits as to who in the population is likely to participate.

2.4.7 Reasons for dog ownership

The most common reasons for dog ownership in this study (mainly "companionship") support previous research (Brodie 1981; Feldmann 1997; Katcher and Friedmann 1982; Leslie and others 1994). The elderly are a group that may be most isolated and would benefit from this companionship, as well as having something to care for and exercise (Katcher and Friedmann 1982), and yet they are less likely to own dogs compared to those people living in large families, with the most companionship already.

In our study, the reasons given for non-ownership were similar to previous findings (Leslie and others 1994) in that 'not enough time' scored highly and 'health reasons' or 'don't like dogs' scored lower, but the most common reason given in our study was 'working or being out all day' rather than 'problem when I go away' or 'housing limitations' as reported previously (Leslie and others 1994; Selby and others 1980). This could be due to the nature of our study area, or the use of boarding kennels possibly being a more commonplace occurrence in recent years. It must be noted that the categories given in this study were slightly different than those in previous studies and this is likely to also affect the types of responses found. The data suggests that some of those without dogs had made a conscious decision not to own a dog (e.g. they are out all day) even though they may like to. Sixty-two percent had owned dogs in the past or lived with them at some point in their lifetime, reflecting the fact that the dog owning population is dynamic rather than fixed. Therefore, as a person's circumstances may change, so may their risk of zoonotic disease through dog ownership.

2.4.8 Single versus multiple dog households

No overall significant effect on dog ownership of cat ownership was identified. However, further analysis suggested that this relationship is more complex than first appears, as multi-dog households were significantly more likely to own a cat or bird than single dog households. It may be that some households generally have more pets, including multiple dogs, cats and birds. Interestingly multi-dog households were also more likely to contain 20-29yr olds, possibly because young adults have the time and energy to own multiple dogs.

2.4.9 General contact with dogs

Clearly in this study, dog owners not only have extensive contact with their own dog, but also have increased contact with other dogs compared to those without dogs. There is a possibility that DO respondents had a greater awareness of dogs in general and this led to recall bias. DO respondents may recall interactions with dogs more readily than DF respondents because of a personal like of them, but this is not supported by the fact that relatively few DF respondents reported that they did not actually like dogs. The increased contact seems to be mainly through walking. It could not be determined if dog owners actually walk more or are more likely to offer walking as a reason for contacting dogs. People who own dogs may also be more likely to walk in areas frequented by other dogs, as these areas provide for socialisation of both dogs and owners, and may provide off lead play areas which are free from hazards. Only limited numbers of such areas may exist, leading to congregation of dogs and owners. People without dogs may actively avoid such areas.

Some dog owners stated employment as a reason for contacting dogs although only a small number actually worked in dog-related professions. The decreased likelihood for dog owners to report contact with a neighbour's dog may be due to recall bias. A dog owner questioned about contact may immediately identify 'walking' as a reason, whereas for non-dog owners, a neighbour's dog may be more likely to be recalled (especially if not liked). Dog owners may also feel that they contact their neighbour's dogs most frequently whilst walking their own dog.

2.4.10 Conclusion

Some households are more likely to own a dog than others and this is associated with a number of factors, including number of people, ages of those people, an adult female in the household and ownership of a horse. Other pets, such as cats or birds, appear to be associated with multiple dog households. Dog owners also have increased contact with dogs in general (other than their own) compared with those not owning a dog, and this contact seems to be mainly through walking. The results of this study may be of use in behavioural research, for provision of veterinary and other services and to inform strategies for quantifying health benefits and risks associated with dog ownership. Detailed studies on the type of dog-human and dog-dog interactions that occur in the pet dog population are now needed.

APPENDIX TO CHAPTER TWO

Table.1. Univariable analysis of contact with other dogs.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
How often							**<0.001**
Never	11	85	0		1		
Very rarely	20	185	-0.18	0.40	0.84	0.38-1.82	
Once a month	10	92	-0.17	0.46	0.84	0.34-2.08	
Once a week	30	160	0.37	0.38	1.45	0.69-3.03	
Several times a week	60	167	1.02	0.35	2.78	1.39-5.56	
Everyday	127	115	2.14	0.35	8.53	4.34-16.79	
Walking							**<0.001**
No	93	650	0		1		
Yes	168	159	2.00	0.16	7.38	5.43-10.04	
Friends							0.25
No	169	555	0		1		
Yes	92	254	0.17	0.15	1.19	0.89-1.60	
Employment							**0.02**
No	234	759	0		1		
Yes	27	50	0.56	0.25	1.75	1.07-2.86	
Neighbours							**0.03**
No	232	673	0		1		
Yes	29	176	-0.48	0.22	0.62	0.40-0.95	
Family							0.34
No	178	577	0		1		
Yes	83	232	0.15	0.15	1.16	0.86-1.57	
Pub							0.44*
No	258	792	0		1		
Yes	3	17	-0.61	0.63	0.54	0.16-1.86	
Other							0.19
No	245	739	0		1		
Yes	16	70	-0.37	0.27	0.69	0.39-1.21	

* = Fisher's exact test P-Value instead of Pearson Chi-Square.

Table 2. Univariable analysis of other types of pet owned.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Cat							0.38
No	210	630	0		1		
Yes	52	182	-0.15	0.18	0.86	0.61-1.21	
Birds							**0.02**
No	246	788	0		1		
Yes	16	24	0.76	0.33	2.14	1.12-4.08	
Fish							**0.02**
No	220	725	0		1		
Yes	42	87	0.46	0.20	1.59	1.07-2.37	
Horse							**<0.01***
No	253	807	0		1		
Yes	9	5	1.74	0.56	5.74	1.91-17.29	
Reptiles / amphibians							0.22
No	256	802	0		1		
Yes	6	10	0.63	0.52	1.88	0.68-5.22	
Small mammals							0.40
No	237	748	0		1		
Yes	25	64	0.21	0.25	1.23	0.76-2.00	
Other pets (inc livestock)							0.37*
No	259	808	0		1		
Yes	3	4	0.85	0.78	2.34	0.52-10.52	

* = Fisher's exact test P-Value instead of Pearson Chi-Square.

Table 3. Univariable analysis of house type and street type.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
House type							0.59
Detached	167	560	0		1		
Semi-detached	80	222	0.19	0.16	1.21	0.89-1.65	
Terraced	17	59	-0.03	0.29	0.97	0.55-1.70	
Flat/apartment	1	6	-0.58	1.08	0.56	0.07-4.68	
Street type							0.86
Cul-de-sac	129	407	0				
Through road	136	440	-0.03	0.14	0.98	0.74-1.29	

Table 4. Univariable analysis of garden and use for recreational purposes.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Garden?							
None	0	4					
Garden	252	775					
Yard	3	7					
Both	6	20					
Recreational							0.98
Never	6	18	0		1		
Rarely	17	52	-0.02	0.55	0.98	0.34-2.87	
Sometimes	46	132	0.04	0.50	1.05	0.39-2.79	
Often	191	596	-0.04	0.48	0.96	0.38-2.46	

Table 5. Univariable analysis of number of persons in household.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Number of Persons							**<0.001**
1	39	177	0		1		
2	85	303	0.24	0.22	1.27	0.83-1.94	
3	50	119	0.65	0.24	1.91	1.18-3.08	
4	56	160	0.46	0.23	1.59	1.00-2.52	
5+	31	41	1.23	0.30	3.43	1.92-6.14	

Table 6. Univariable analysis of gender in household.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Males							**<0.01**
0	37	128	0		1		
1	122	459	-0.08	0.21	0.92	0.61-1.39	
2	70	152	0.47	0.24	1.59	1.00-2.53	
3+	31	61	0.56	0.29	1.76	1.00-3.10	
Females							**0.001**
0	10	89	0		1		
1	152	485	1.02	0.65	2.79	1.42-5.50	
2	69	158	1.36	0.36	3.89	1.91-7.92	
3+	29	68	1.33	0.40	3.80	1.73-8.32	
Presence of adult males							0.31
No	40	144	0		1		
Yes	217	640	0.20	0.20	1.22	0.83-1.79	
Presence of adult females							**<0.01**
No	12	84	0		1		
Yes	245	700	0.90	0.32	2.45	1.32-4.56	
Adult gender household							**0.01**
All male	12	84	0		1		
All female	40	144	0.66	0.36	1.94	0.97-3.91	
Mixed male/female	205	554	0.95	0.32	2.59	1.39-4.84	

Table 7a. Univariable analysis of ages of people in households.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Number of persons 5yrs or under							0.27
0	242	721	0		1		
1	12	60	-0.51	0.32	0.60	0.32-1.13	
2+	6	19	-0.06	0.47	0.94	0.37-2.38	
Presence of person 5yrs or under							0.15
No	242	721	0		1		
Yes	18	79	-0.38	0.27	0.68	0.40-1.16	
Number of persons 6 to 15 yrs							0.11
0	190	631	0		1		
1	37	99	0.22	0.21	1.24	0.82-1.87	
2+	33	70	0.45	0.23	1.57	1.00-2.44	
Presence of 6-15 yr old							0.05
No	190	631	0		1		
Yes	70	169	0.32	0.16	1.38	1.00-1.90	
Number of persons 16 to 19 yrs							**0.001**
0	209	709	0		1		
1	39	78	0.53	0.21	1.70	1.12-2.57	
2+	12	13	1.14	0.41	3.13	1.41-6.97	
Presence of 16-19 yr old							**0.001**
No	209	709	0		1		
Yes	51	91	0.64	0.19	1.90	1.31-2.77	
Number of persons 20 to 29 yrs							**0.03**
0	202	670	0		1		
1	41	78	0.56	0.21	1.74	1.16-2.63	
2+	17	52	0.08	0.29	1.08	0.61-1.92	
Presence of 20-29 yr old							**0.03**
No	202	670	0		1		
Yes	58	130	0.39	0.18	1.48	1.05-2.09	
Number of persons 30 to 59 yrs							**<0.001**
0	61	286	0		1		
1	55	172	0.40	0.21	1.50	0.99-2.26	
2+	144	342	0.68	0.17	1.97	1.41-2.77	
Presence of 30-59 yr old							**<0.001**
No	61	286	0		1		
Yes	199	514	0.60	0.16	1.82	1.32-2.50	
Number of persons 60 to 74 yrs							0.28
0	198	570	0		1		
1	35	122	-0.19	0.20	0.83	0.55-1.24	
2	27	108	-0.32	0.23	0.72	0.46-1.13	
Presence of 60-74 yr old							0.12
No	198	570	0		1		
Yes	62	230	-0.25	0.17	0.78	0.56-1.07	
Number of persons 75 yrs or above							0.20
0	243	718	0		1		
1	13	60	0.45	0.31	0.64	0.35-1.19	
2+	4	22	0.62	0.55	0.54	0.18-1.57	
Presence of person 75 yrs or above							0.07
No	243	718	0		1		
Yes	17	82	-0.49	0.28	0.61	0.36-1.05	

Table 7b. Univariable analysis of combining age categories of people in households (effectively to presence of children, children not including young, or elderly).

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Number of persons 19yrs or under							**0.03**
0	157	544	0		1		
1	34	98	0.18	0.22	1.20	0.78-1.85	
2	47	123	0.28	0.19	1.32	0.91-1.94	
3+	22	35	0.78	0.29	2.18	1.24-3.82	
Presence of person 19yrs or under							**0.02**
No	157	544	0		1		
Yes	103	256	0.33	0.15	1.39	1.04-1.86	
Number of persons 6 to 19yrs							**<0.01**
0	164	591	0		1		
1	38	91	0.41	0.21	1.50	0.99-2.28	
2	40	93	0.44	0.21	1.55	1.03-2.33	
3+	18	25	0.95	0.32	2.59	1.38-4.87	
Presence of 6-19 yr old							**0.001**
No	164	591	0		1		
Yes	96	209	0.50	0.15	1.66	1.23-2.23	
Number of persons 60yrs or above							0.05
0	184	501	0		1		
1	42	156	-0.31	0.19	0.73	0.50-1.07	
2+	34	143	-0.43	0.21	0.65	0.43-0.98	
Presence of person 60yrs or above							**0.02**
No	184	501	0		1		
Yes	76	299	-0.36	0.15	0.69	0.51-0.94	

Table 8. Univariable analysis of occupational classification of people in households (continued next page).

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Presence of Managers or senior officials							0.30
No	222	703	0		1		
Yes	38	97	0.22	0.21	1.24	0.83-1.86	
Number of Managers or senior officials in house							0.31
0	222	703	0		1		
1	36	86	0.28	0.22	1.33	0.87-2.01	
2	2	11	-0.55	0.77	0.58	0.13-2.62	
Presence of Professionals							0.95
No	218	672	0		1		
Yes	42	128	0.01	0.19	1.01	0.69-1.48	
Number of Professionals in house							0.43
0	218	672	0		1		
1	39	109	0.10	0.20	1.10	0.74-1.64	
2+	3	19	-0.72	0.62	0.49	0.14-1.66	
Presence of Associate professional and technical							**0.04**
No	211	691	0		1		
Yes	49	109	0.39	0.19	1.47	1.02-2.13	
Number of Associate professional and technical in house							0.06
0	211	691	0		1		
1	45	93	0.46	0.20	1.58	1.08-2.34	
2	4	16	-0.20	0.56	0.82	0.27-2.48	
Presence of Administrative and secretarial							0.86
No	218	667	0		1		
Yes	42	133	-0.03	0.19	0.97	0.66-1.41	
Number of Administrative and secretarial in house							0.86
0	218	667	0		1		
1	39	120	-0.01	0.20	0.99	0.67-1.47	
2+	3	13	-0.34	0.65	0.71	0.20-2.50	
Presence of Skilled trades							**0.001**
No	200	688	0		1		
Yes	60	112	0.61	0.18	1.84	1.30-2.62	
Number of Skilled trades in house							**0.001**
0	200	688	0		1		
1	50	102	0.52	0.19	1.69	1.16-2.45	
2+	10	10	1.24	0.45	3.44	1.41-8.38	
Presence of Personal service							**<0.001**
No	228	755	0		1		
Yes	32	45	0.86	0.24	2.35	1.46-3.79	
Number of Personal service in house							**0.001**
0	228	755	0		1		
1	29	39	0.90	0.26	2.46	1.49-4.07	
2	3	6	0.50	0.71	1.66	0.41-6.67	

* = Fisher's exact test P-Value instead of Pearson Chi-Square.

Table 8 (continued). Univariable analysis of occupational classification of people in households.

Variable	DO (n)	DF (n)	Coef	SE	OR	95% CI	P-value
Presence of Sales and customer service							0.51
No	232	725	0		1		
Yes	28	75	0.15	0.23	1.17	0.74-1.85	
Number of Sales and customer service in house							0.63
0	232	725	0		1		
1	25	70	0.11	0.24	1.12	0.69-1.80	
2	3	5	0.63	0.73	1.88	0.44-7.99	
Presence of Process, plant and machines							0.38
No	239	748	0		1		
Yes	21	52	0.23	0.27	1.26	0.75-2.14	
Presence of Elementary							0.55
No	251	778	0		1		
Yes	9	22	0.24	0.40	1.27	0.58-2.79	
Presence of Unemployed							**<0.01***
No	252	795	0		1		
Yes	8	5	1.62	0.57	5.05	1.64-15.57	
Presence of Retired							**<0.01**
No	193	511	0		1		
Yes	67	289	-0.49	0.16	0.61	0.45-0.84	
Number of Retired in house							**0.01**
0	193	511	0		1		
1	38	163	-0.48	0.20	0.62	0.42-0.91	
2+	29	126	-0.50	0.22	0.61	0.39-0.94	
Presence of Looking after home/family							0.28
No	238	748	0		1		
Yes	22	52	0.28	0.26	1.33	0.79-2.24	
Presence of Full-time student							**0.01**
No	163	570	0		1		
Yes	97	230	0.39	0.15	1.47	1.10-1.98	
Number of Full-time students in house							**0.03**
0	163	570	0		1		
1	41	97	0.39	0.21	1.48	0.99-2.21	
2+	56	133	0.39	0.18	1.47	1.03-2.11	
Presence of Permanently sick / disabled							0.05*
No	253	793	0		1		
Yes	7	17	1.14	0.54	3.13	1.09-9.02	

* = Fisher's exact test P-Value instead of Pearson Chi-Square.

Table 9. Univariable analysis of pet ownership for single dog and multiple dog households.

Variable	Single (n)	Multiple (n)	Coef	SE	OR	95% CI	P-value
Cat							**0.01**
No	168	42	0		1		
Yes	33	19	0.83	0.34	2.30	1.19-4.45	
Birds							**<0.01***
No	194	52	0		1		
Yes	7	9	1.57	0.53	4.80	1.71-13.49	
Fish							0.20
No	172	48	0		1		
Yes	29	13	0.47	0.37	1.61	0.78-3.33	
Horse							1.00*
No	194	59	0		1		
Yes	7	2	-0.06	0.82	0.94	0.19-4.65	
Reptiles and amphibians							0.14*
No	198	58	0		1		
Yes	3	3	1.23	0.83	3.41	0.67-17.37	
Small mammals							0.68
No	181	56	0		1		
Yes	20	5	-0.21	0.52	0.81	0.29-2.25	
Other pets including livestock							0.14*
No	200	59	0		1		
Yes	1	2	1.91	1.23	6.78	0.60-76.09	
Number of persons							0.33
1	34	5	0		1		
2	63	22	0.86	0.54	2.37	0.83-6.83	
3	36	14	0.97	0.57	2.64	0.86-8.13	
4	41	15	0.91	0.57	2.49	0.82-7.55	
5+	26	5	0.26	0.68	1.31	0.34-5.00	
Presence of persons 5 yrs or under							0.26*
No	183	59	0		1		
Yes	16	2	-0.95	0.76	0.39	0.09-1.74	
Presence of persons 6 to19yrs							
No	121	43	0		1		
Yes	78	18	-0.43	0.62	0.65	0.35-1.21	
Presence of persons 20 to 29 yrs							**0.03**
No	161	41	0		1		
Yes	38	20	0.73	0.33	2.07	1.09-3.92	
Presence of persons 30 to 59 yrs							0.14
No	51	10	0		1		
Yes	148	51	0.56	0.38	1.76	0.83-3.72	
Presence of over 60s							0.56
No	139	45	0		1		
Yes	60	16	-0.19	0.33	0.82	0.43-1.57	
Age group							0.09$
1 (Over 60s)	44	7	0		1		
2 (Families)	34	17	1.15	0.50	3.14	1.17-8.44	
3 (Families)	55	13	0.40	0.51	1.49	0.55-4.04	
4 (Singles/couples adults)	35	14	0.92	0.52	2.51	0.92-6.90	
5 (Young families)	15	2	-0.18	0.86	0.84	0.16-4.48	
6 (Older families)	16	8	1.15	0.59	3.14	0.98-10.7	

* = Fisher's exact test P-Value instead of Pearson Chi-Square.
$ = 1 or more cells with expected counts less than 5.

Table 9 (continued). Univariable analysis of pet ownership for single dog and multiple dog households.

Variable	Single (n)	Multiple (n)	Coef	SE	OR	95% CI	P-value
Presence of Managers and senior officials							0.39
No	172	50	0		1		
Yes	27	11	0.34	0.39	1.40	0.65-3.02	
Presence of Professionals							0.73
No	166	52	0		1		
Yes	33	9	-0.14	0.41	0.87	0.39-1.94	
Presence of Associate professional and technical							0.35
No	164	47	0		1		
Yes	35	14	0.33	0.36	1.40	0.69-2.81	
Presence of Admin and secretarial							0.95
No	167	51	0		1		
Yes	32	10	0.02	0.40	1.02	0.47-2.22	
Presence of Skilled trade							0.98
No	153	47	0		1		
Yes	46	14	-0.01	0.35	0.99	0.50-1.96	
Presence of Personal service							0.51
No	176	52	0		1		
Yes	23	9	0.28	0.42	1.32	0.58-3.04	
Presence of Sales and customer service							0.09
No	174	58	0		1		
Yes	25	3	-1.02	0.63	0.36	0.10-1.24	
Presence of Process, plant and machines							1.00*
No	183	56	0		1		
Yes	16	5	0.02	0.53	1.02	0.36-2.91	
Presence of Elementary							1.00*
No	192	59	0		1		
Yes	7	2	-0.07	0.82	0.93	0.19-4.60	
Presence of Unemployed							0.40*
No	194	58	0		1		
Yes	5	3	0.70	0.75	2.01	0.47-8.65	
Presence of Retired							0.57
No	146	47	0		1		
Yes	53	14	-0.20	0.34	0.82	0.42-1.61	
Presence of looking after home/family							0.66
No	183	55	0		1		
Yes	16	6	0.22	0.50	1.25	0.47-3.34	
Presence of Full-time students							0.82
No	124	39	0		1		
Yes	75	22	-0.07	0.30	0.93	0.51-1.69	
Presence of Permanently sick or disabled							0.36*
No	195	58	0		1		
Yes	4	3	0.92	0.77	2.52	0.55-11.59	
Occupation group							0.88$
1 All sales	12	3	0		1		
2 All skilled trade	20	8	0.47	0.77	1.60	0.35-7.23	
3 All admin	24	7	0.15	0.78	1.17	0.26-5.33	
4 All retired	40	8	-0.22	0.75	0.80	0.18-3.50	
5 All personal service	23	9	0.45	0.76	1.57	0.36-6.89	
6 All associate professionals	25	10	0.47	0.75	1.60	0.37-6.91	
7 Process/plant and elementary.	24	9	0.41	0.75	1.50	0.34-6.58	
8 All professional	17	3	-0.35	0.90	0.71	0.12-4.11	
9 All managers	14	4	0.13	0.86	1.14	0.21-6.16	

Table 10. Multivariable model excluding households with over 60s (age group 1) or retired (occupation group 4) persons (n=722). Hosmer-Lemeshow statistic P-value =0.9.
Original variables Horse, Birds, Fish, Number of persons, Age group, Occupation group, Presence of adult male, Presence of adult female.

Variable	Coef	SE	OR	95% CI	P-value
Horse					**0.02**
No	0		1		
Yes	1.67	0.70	5.31	1.34-20.99	
Number of persons					**0.06**
1	0		1		
2	0.15	0.41	1.16	0.52-2.59	
3	0.48	0.51	1.62	0.60-4.39	
4	0.28	0.52	1.32	0.48-3.63	
5+	1.09	0.55	2.98	1.02-8.77	
Age group (from cluster analysis)					**0.08**
5 Young families	0		1		
2 Families	0.83	0.33	2.31	1.21-4.41	
3 Families	0.80	0.31	2.23	1.21-4.09	
4 Singles/couples adults	0.90	0.44	2.46	1.04-5.83	
6 Older families	1.02	0.41	2.76	1.22-6.22	
Presence of adult female					**0.05**
No	0		1		
Yes	1.01	0.52	2.75	1.00-7.61	

CHAPTER THREE

DOG-HUMAN AND DOG-DOG INTERACTIONS IN A UK PET DOG COMMUNITY

This Chapter has been published as a paper:
Westgarth, C., Pinchbeck, G. L., Bradshaw, J. W. S., Dawson, S., Gaskell, R. M. & Christley, R. M. (2008) Dog-human and dog-dog interactions of 260 dog-owning households in a community in Cheshire. Veterinary Record, 162, 436-442.

ABSTRACT

The interactions that occur between dogs, and between dogs and humans, are of interest to behavioural, welfare, psychological and social sciences. As dogs are a potential source of zoonotic infections to humans, especially for immunocompromised people, the young and the elderly, such interactions may impact on public health. Pathogens may transfer through direct contact (handling the dog or excretions such as faeces) or indirectly (through contaminated bedding or other objects). Dogs may also transmit (zoonotic or non-zoonotic) infections to each other through their interactions or environment. Despite their popularity as pets, there have been no in-depth studies into the contacts that occur between dogs, and between dogs and people.

This study investigated the nature and frequency of these contacts using a questionnaire survey of 260 dog owning households in a community in Cheshire, UK. We found that these contacts were highly variable and affected by: size, gender and age of dog; individual dog behaviours; human behaviours and human preferences in management of the dog. A number of situations were identified that may be of particular importance in relation to zoonoses, including: sleeping areas, playing behaviours, greeting behaviours, food sources, walking, disposal of faeces, veterinary preventive treatment and general hygiene.

3.1 INTRODUCTION

There are approximately 6.5 million dogs owned in the UK (PFMA 2004), which equates to 1 dog for every 9 people and every 4 households (Office for National Statistics 2001a). Dog ownership is associated with many benefits for people, including companionship and physiological and psychological health (Friedmann 1995; Headey 2003; Katcher 1981; Katcher and Friedmann 1982; McNicholas and others 2005). Despite this, concerns about negative aspects of dog ownership, recently highlighted by Jackson (2005) include dog bites, public nuisance, welfare, and risks to public health from zoonoses.

At least 30 to 40 diseases of companion animals are transmissible to humans (Greene and Levy 2006), including parasitic, bacterial, fungal and viral diseases (Geffray and Paris 2001). Examples in dogs in the UK include *Campylobacter* spp., *Salmonella* spp., *Toxocara canis* (Greene and Levy 2006; Tan 1997) and Methicillin-Resistant *Staphylococcus aureus* (MRSA) (Cefai and others 1994; Greene and Levy 2006). Ownership of pet puppies has been reported to be an independently associated risk factor in campylobacter illness in young children in Australia (Tenkate and Stafford 2001) and exposure to diarrhoeic animals has been associated with a three-fold increase in the risk of *C.jejuni/coli* enteritis in humans (Saeed and others 1993).

Little detail is known about the nature and frequency of contacts between pet dogs and their owners or other people. However, in order to accurately assess the disease transmission risk from pets to humans it is important that such factors are evaluated (Wieland and others 2005). A smaller questionnaire study has been conducted in Scotland since our study was performed, and presented at a conference (Heller and others 2007); those results will compliment findings from our study in order to evaluate this area. The nature of the pathogen and its mode of transmission will be crucial when considering potential risk. Dog owning activities involving close contact with humans include: sleeping, playing, eating, greeting, disposal of faeces and general physical contact through affection such as cuddling and stroking.

Similarily, little is known about the contact between dogs that could transmit infection through a population, for example during interactions between dogs whilst walking or through indirect contact during investigation of other dog's excreta. Bradshaw and Lea (1992) characterised the behaviour sequences that occur during dog-dog interactions in popular walking areas, but did not quantify the frequency of interactions, an important factor affecting the risk of pathogen transmission. Opportunities for pathogen transmission between dogs will be affected by human preferences such as the frequency of walks and how often the dog is let off lead, as well as individual dog behaviours.

Primarily, it is a combination of both human and dog behaviours that determine where the dog goes and what it does. Studying interactions is not only of zoonotic importance, but of behavioural, welfare, psychological and social science interest. The aim of this study was to investigate and quantify the direct and indirect contacts between dogs, and between dogs and people, that occur in a community of pet dogs. A particular focus of this study was to evaluate contact behaviours that may be associated with transmission of pathogens of zoonotic importance.

3.2 METHODS

3.2.1 Survey method

In a door-step survey of 1278 households in a community in Cheshire, UK (Chapter 2), the owners of 327 dogs were identified and recruited into the study. Basic demographic information was collected for each dog at the time of recruitment. The 260 dog owning households were asked to complete questionnaires, containing multiple choice and open-ended questions, which had been pre-tested, revised and then piloted on 12 dog owning households in a nearby area. It was designed using an automated content capture system, TELE*form* v9.1 (Verity Software, 2005) (and can be viewed in the General Appendix). Questions were selected specifically to investigate the behaviours with potential for zoonotic pathogen transmission and covered a variety of topics: where the dog sleeps and is allowed access, the games it plays, its health, diet, walk frequency and behaviour when greeting people and other dogs. The questionnaires were returned between July and October 2005. Households that had not returned their questionnaires after 2 weeks were sent a reminder postcard, and if they had still not returned their questionnaire after another 4-6 weeks they were sent another copy of the questionnaire. Incentives to participate included money-off vouchers for dog food and a local boarding kennels, which were provided following return of the questionnaire.

3.2.2 Data analysis

The data were managed in a Microsoft Access database (Microsoft Corporation, 2003) and analysed using Minitab (Minitab release 14.2, Minitab Inc, 2005), SPSS (SPSS 13.0 for Windows, SPSS Inc, 2004) and Excel (Microsoft Corporation, 2003). Chi-squared tests were used to investigate associations between answers to questions and categorical factors such as gender and size of dog. Many of the variables were measured as never, rarely, sometimes, often. This ordinal outcome was assessed using ordinal logistic regression analysis for the continuous variable age, with the lowest category as never. The association between the ordinal variables 'likely to greet dogs' and 'likely to greet people' was tested using the Gamma statistic (Siegal and Castellan Jr 1988). Questions about the respondents' views on the positioning and emptying of dog-waste bins in the area were used to introduce the subject of picking-up faeces. For those households where one main person performed dog duties, this person would have been asked to complete the questionnaire, and the response to the questions on picking up faeces were compared for male and female owners using Chi-squared tests.

3.3 RESULTS

A summary of the responses to each individual question is given in the General Appendix.

3.3.1 Demographic information

Of the dogs initially recruited into the study, most dogs were of a named breed (78%) as opposed to crossbreeds or mixed breeds. Gundogs were the most popular UK Kennel Club category (25%) followed by mixed/cross breeds (23%). Labradors were the most popular of the individual breeds (15%) followed by Jack Russell Terriers (13%). Other popular breeds included Cocker Spaniel (8%), Border Collie (7%), West Highland Terrier (7%), German Shepherd (6%), Cavalier/King Charles Spaniel (4%), Golden Retriever (4%) and Springer Spaniel (4%). Approximately equal numbers of dogs were small, medium or large, with very few toy or giant sized. The mean approximate or known age (n=317) was 6.5 years (SD 3.9), with a maximum of 19 years (Fig.3.1). There were slightly more females (173) than males (154), and a lower percentage of males had been neutered (53%) compared to females (73%); the odds of females being neutered was 2.3 (95%CI 1.4-3.7) times greater than for males. The majority of dogs were acquired by the current owner from the person who bred the dog (59%). Seventy-one percent of owners had owned the dog in question since it was a puppy (12 weeks old or under), the maximum age of dog when acquired was 15 years.

Of the 327 dogs recruited into the study, completed questionnaires were returned for 85% (279). Twelve percent of households with one or two dogs did not respond, compared with 43% of three-dog households.

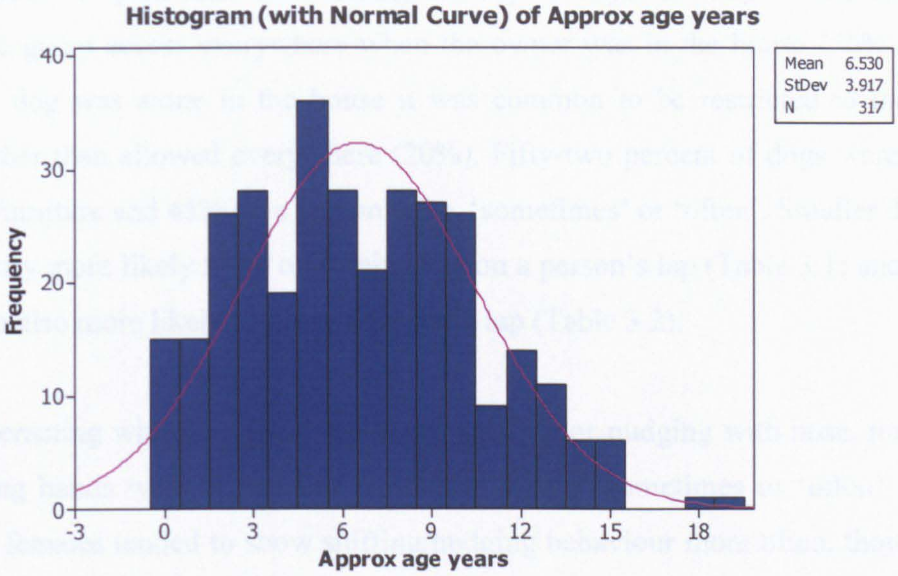


Figure 3.1 Age distribution of dogs (n=317).

3.3.2 Diet and healthcare

Over half (56%) of dogs had one main person performing main dog duties such as feeding and exercising. Seventy-nine percent of dogs were fed in the kitchen. The most popular dog food was dry complete commercial dog food, though one dog was fed raw meat as part of its main diet. Eighty-three percent of dogs were never fed raw meat. Commercial dog treats were fed to 85% of dogs 'sometimes' or 'often'. Human food tit-bits were fed to dogs 'sometimes' or 'often' from the hand (62%), in the dog's bowl (69%), straight from the plate (11%) or off the floor (37%). Six percent of dogs 'sometimes' or 'often' found and ate raw carcasses, 25% rolled in them or faeces, and 6% 'sometimes' found and ate dog faeces. Eighty-four percent of dogs had visited a veterinary surgeon in the past year; 4% had visited because of vomiting and/or diarrhoea. Sixty-two percent of the dogs had been vaccinated in the past year. Flea treatment had been given recently (in the past three months) to 53%, and worming treatment to 58%.

3.3.3 Dog-human and dog-dog interactions inside the home

The most common sleeping place of the dog was in the kitchen (42%'always' or 'often'); nineteen percent slept on the bedroom floor 'always' or 'often' and 14% on a human bed. During the day, the living area was the most popular place for dogs to rest, with 60% being there 'always' or 'often'. Only 4% of dogs slept outside 'always' or 'often' but 29% spent time there during the day 'always' or 'often'. The majority of dogs were given access everywhere when the owner was in the house (56%) but then when the dog was alone in the house it was common to be restricted to the kitchen (24%) rather than allowed everywhere (20%). Fifty-two percent of dogs were reported to lie on furniture and 45% on a person's lap, 'sometimes' or 'often'. Smaller dogs were significantly more likely to lie on furniture or on a person's lap (Table 3.1) and younger dogs were also more likely to lie on a person's lap (Table 3.2).

When interacting with household members, sniffing or nudging with nose, jumping up and licking hands were commonly reported to occur 'sometimes or 'often' (Fig.3.2). Neutered females tended to show sniffing/nudging behaviour more often, though group sizes were small (Table 3.3). Smaller dogs were reported to jump up more often than larger dogs (Table 3.1). Ordinal logistic regression identified jumping up, licking faces and lickings hands of household members as significantly more common in younger dogs (Table 3.2). The most common type of game played with the dog was to fetch a ball or other object (77% 'sometimes' or 'often'). Larger dogs were reported to play fetch more often than smaller dogs (Table 3.1), although this was only significant if those respondents not reporting playing fetch but reporting for other games were categorised as 'never' for fetch. There were significant differences in the frequency of fetch games by gender/neuter status (Table 3.3) with entire females reportedly playing more fetch games. Tug-of-war was more likely to be played by smaller dogs than larger (Table 3.1). Ordinal logistic regression showed that younger dogs played all the games more frequently (Table 3.2).

Table 3.1 Significant (P<0.05) associations between contact behaviours and size of dog reported by owner questionnaire for 279 dogs in Cheshire.

For tables including non-significant variables please see Appendix to Chapter 3, Table 1.

Covariate	**Size**	**Never n (%)**	**Rarely n (%)**	**Sometimes n (%)**	**Often n (%)**	**P-value**
Lie on furniture	Toy/small	17 (18)	10 (11)	29 (31)	37 (40)	<0.001
	Medium	37 (39)	9 (10)	22 (23)	26 (28)	
	Large/giant	45 (58)	8 (10)	16 (21)	8 (10)	
Lie on persons lap	Toy/small	9 (10)	13 (14)	26 (29)	43 (47)	<0.001
	Medium	33 (36)	21 (23)	24 (26)	13 (14)	
	Large/giant	59 (72)	9 (11)	12 (15)	2 (2)	
Jumps up at household members	Toy/small	3 (3)	9 (10)	32 (34)	49 (53)	<0.001
	Medium	17 (18)	11 (12)	29 (32)	35 (38)	
	Large/giant	22 (28)	19 (24)	23 (29)	14 (18)	
Jumps up at visitors	Toy/small	7 (8)	11 (12)	33 (37)	39 (43)	<0.001
	Medium	19 (21)	14 (15)	30 (33)	28 (31)	
	Large/giant	33 (41)	13 (16)	21 (26)	13 (16)	
Fetch games (missing assumed as "never")	Toy/small	24 (24)	10 (10)	21 (21)	44 (44)	0.01*
	Medium	10 (11)	5 (5)	24 (25)	56 (59)	
	Large/giant	8 (10)	6 (7)	31 (37)	39 (46)	
Tug-of-war games	Toy/small	9 (10)	7 (8)	35 (40)	36 (41)	0.02
	Medium	16 (18)	18 (20)	24 (27)	31 (35)	
	Large/giant	21 (25)	10 (12)	28 (34)	24 (29)	
		< once /week	**1-sev /week**	**1-2 /day**	**3+ /day**	
Walk frequency	Toy/small	5 (5)	27 (27)	55 (56)	12 (12)	0.04
	Medium	1 (1)	14 (15)	63 (66)	17 (18)	
	Large/giant	0 (0)	14 (17)	54 (64)	16 (19)	

* P=0.08 if missing data removed rather than assumed to be "never".

Table 3.2 Significant (P<0.05) associations between contact behaviours and age of dog (identified using ordinal logistic regression) reported by owner questionnaire for 279 dogs in Cheshire.
For tables including non-significant variables please see Appendix to Chapter 3, Table 2.

Covariate	Never	Rarely	Sometimes	Often	Odds ratio (95% CI)[1]	P-value
	Mean approx age in years (SD) in each category					
Lie on persons lap	7.6 (4.1)	7.3 (3.6)	6.1 (3.8)	5.4 (3.6)	1.1 (1.1-1.2)	<0.001
Jumps up at household members	8.2 (3.3)	8.2 (3.4)	6.3 (4.1)	5.4 (3.8)	1.2 (1.1-1.2)	<0.001
Jumps up at visitors	8.7 (3.5)	8.6 (3.6)	6.2 (3.7)	4.4 (3.3)	1.3 (1.2-1.3)	<0.001
Lick faces of household members	8.0 (3.8)	6.4 (4.0)	6.4 (3.6)	4.5 (3.6)	1.2 (1.1-1.2)	<0.001
Lick faces of visitors	7.6 (3.8)	5.2 (3.8)	6.7 (3.9)	2.0 (2.0)	1.2 (1.1-1.3)	<0.001
Lick hands of household members	7.2 (3.4)	7.1 (4.2)	6.7 (4.0)	5.5 (4.1)	1.1 (1.0-1.1)	0.01
Fetch games	8.8 (3.6)	8.4 (3.9)	7.3 (3.8)	5.6 (3.7)	1.2 (1.1-1.3)	<0.001
Tug-of-war games	7.6 (3.8)	7.8 (3.4)	7.0 (4.1)	5.1 (3.5)	1.1 (1.1-1.2)	<0.001
Rough-and-tumble games	7.5 (4.0)	8.1 (3.8)	6.3 (3.5)	5.1 (4.0)	1.1 (1.1-1.2)	<0.001
Chase games	8.1 (3.7)	7.5 (4.3)	5.7 (3.5)	5.3 (3.8)	1.2 (1.1-1.2)	<0.001
Playful with other dogs	8.7 (3.9)	6.0 (3.5)	6.5 (3.8)	5.6 (3.6)	1.1 (1.1-1.2)	0.001
Ignores other dogs	6.0 (4.5)	6.6 (3.8)	6.9 (3.4)	7.9 (4.0)	0.9 (0.9-1.0)	0.03
	0-15mins	16-30mins	31-60mins	Over 60mins		
Walk length	8.6 (4.1)	7.0 (4.2)	6.2 (3.7)	6.5 (3.1)	1.1 (1.0-1.1)	0.04

[1]The odds ratios presented are from Ordinal logistic regression with the lowest category as never; an OR<1 indicates that as age increases the probability of being in the higher categories increases; an OR>1 indicates that as age increases the probability of being in the lower categories increases.

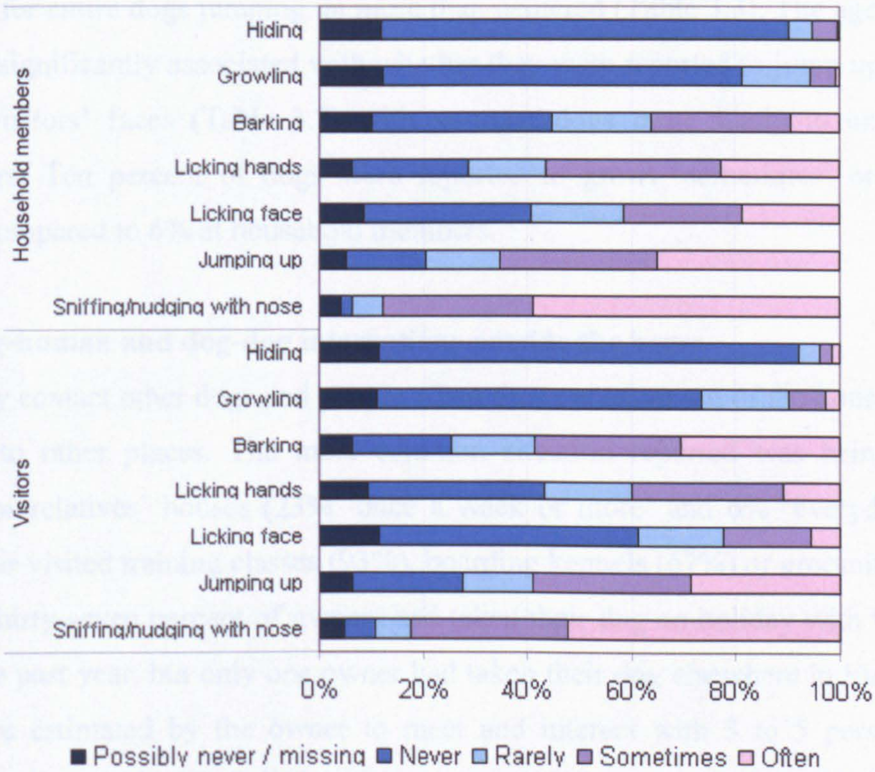


Figure 3.2 Frequency of behaviours exhibited when interacting with household members or greeting visitors reported by owner questionnaire for 279 dogs in Cheshire.

Table 3.3 Significant (P<0.05) associations between contact behaviours and sex of dog, reported by owner questionnaire for 279 dogs in Cheshire.

For tables including non-significant variables please see Appendix to Chapter 3, Tables 3-5.

Covariate	Gender	Never n (%)	Rarely n (%)	Sometimes n (%)	Often n (%)	P-value
Sniffs/nudges with nose	Entire male	2 (4%)	1 (2%)	19 (33%)	35 (61%)	-
Household members	Neutered male	2 (3%)	5 (7%)	24 (34%)	39 (56%)	
	Entire female	0 (0%)	4 (12%)	14 (42%)	15 (45%)	
	Neutered female	3 (3%)	4 (4%)	22 (22%)	73 (72%)	
Fetch games	Entire male	7 (13%)	9 (16%)	19 (34%)	21 (38%)	0.04
	Neutered male	7 (10%)	5 (7%)	22 (31%)	37 (52%)	
	Entire female	2 (6%)	0 (0%)	5 (16%)	25 (78%)	
	Neutered female	11 (11%)	6 (6%)	30 (30%)	53 (53%)	
Jumps up at visitors	Entire	14 (16%)	9 (10%)	33 (38%)	31 (36%)	0.06
	Neutered	45 (27%)	29 (17%)	49 (29%)	45 (27%)	
Sniffs other dogs	Male	7 (5%)	12 (9%)	32 (25%)	77 (60%)	0.03
	Female	7 (5%)	6 (5%)	54 (41%)	64 (49%)	

The most common frequency reported for adult visitors to the house was several times a week (42%), whereas for children it was once a week (20%) or once every several months (21%), but some households had adult or child visitors everyday (23% and 12% respectively). The most common behaviours reported when greeting visitors were sniffing or nudging with nose, jumping up and barking (Fig.3.2). Smaller dogs were reported to jump up at visitors more often than larger (Table 3.1), and there was some evidence for entire dogs jumping up more than neutered (Table 3.3). The age of the dog was also significantly associated with whether they were reported to jump up at visitors or lick visitors' faces (Table 3.2) with younger dogs more likely to exhibit these behaviours. Ten percent of dogs were reported to growl 'sometimes' or 'often' at visitors compared to 6% at household members.

3.3.4 Dog-human and dog-dog interactions outside the home

Dogs may contact other dogs and people when they are taken out of the household, on a walk or to other places. The most common situation reported was being taken to friends' or relatives' houses (23% 'once a week or more' and 6% 'everyday'). Most dogs never visited training classes (93%), boarding kennels (67%) or grooming parlours (67%). Thirty-seven percent of owners had taken their dog on holiday with them in the UK in the past year, but only one owner had taken their dog elsewhere in Europe. Most dogs were estimated by the owner to meet and interact with 3 to 5 persons a day, outside the household (Fig.3.3), but there was a significant trend (P=0.001) for meeting more people at weekends than weekdays. This trend was also seen when estimating number of dogs met and interacted with per day, with 1 to 2 being most common for week days and 3 to 5 at weekends (P=0.01, Fig.3.3). The majority of dogs 'often' or 'sometimes' physically interacted with people or other dogs encountered outside the home (both 76%), with evidence of 'gregarious dogs' that tended to interact with both dogs and people (Gamma statistic value 0.39, P<0.001). Common behaviour types reported as 'sometimes' or 'often' when interacting with another dog included playful (59%), sniffing (81%), ignore (42%) and aggression (24%). There were significant differences between the frequency of reports of sniffing behaviour for male and female dogs (Table 3.3), although there was no significance in a Chi-square test for trend. Younger dogs were more likely to play with other dogs and less likely to ignore other dogs (Table 3.2).

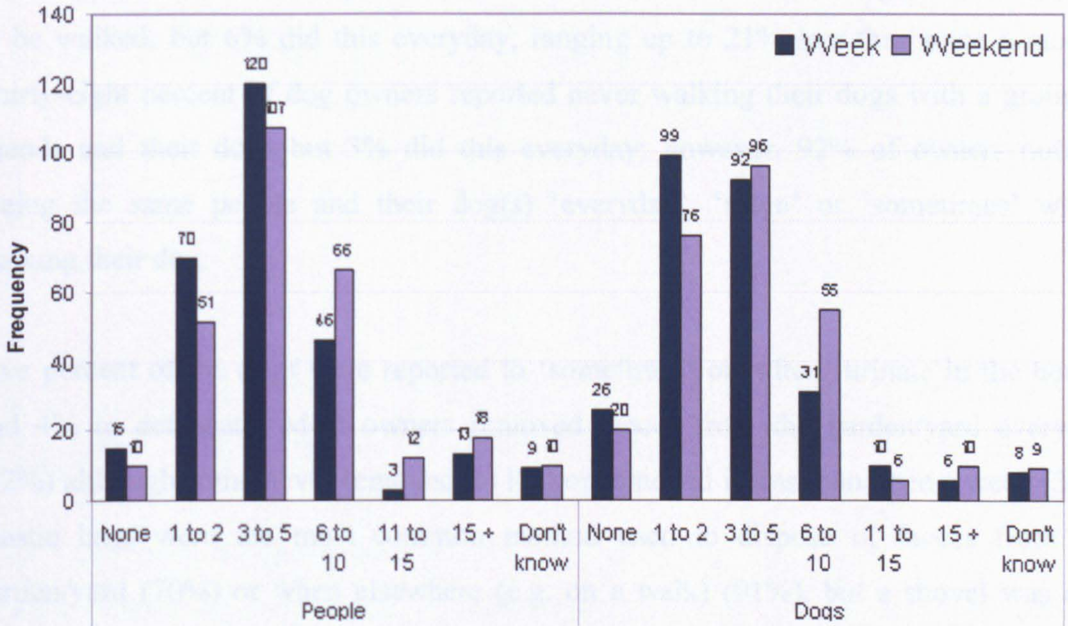


Figure 3.3. Estimations of number of people and number of dogs met and interacted with by the dog per day reported by owner questionnaire for 279 dogs in Cheshire.

Eighty-three percent of the dogs were confined to a secure area and never roamed unattended away from the premises; only 1% were reported to be allowed to roam freely, although this may be an underestimation due to the sensitive nature of the question. Most dogs were walked twice (32%) or once (30%) a day. Only 3% were never walked or walked less than once a week, but these included some young puppies and old dogs. Large or medium dogs were walked more often than smaller (Table 3.1, Chi squared for trend P=0.001).

Six percent of the dogs were never on a lead when walked. In contrast, 14% of dogs were never allowed off the lead. Of the dogs allowed off lead on walks, the majority (67%) were always within sight. Most dog owners walked their dog for between 16 minutes and 1 hour each time. Younger dogs were more likely to be walked for longer periods than older dogs (Table 3.2). Approximately half of the dogs were walked at regular times each day, with 6-9am being most common, but 9am-12pm, 3-6pm and 6-9pm were also frequently used. Countryside (75%) and beach/marsh (64%) were common walking areas for this community, located next to the Dee Estuary. Sixty-nine percent of owners reported to walk regularly in the same places. Twenty-seven percent of owners never took the dogs out of the local area (in the car or using public transport) to be walked; but 6% did this everyday, ranging up to 21% less than once a month. Thirty-eight percent of dog owners reported never walking their dogs with a group of friends and their dogs but 3% did this everyday; however, 92% of owners noticed seeing the same people and their dog(s) 'everyday', 'often' or 'sometimes' whilst walking their dog.

Five percent of the dogs were reported to 'sometimes' or 'often' urinate in the house, and 4% to defaecate. Most owners removed faeces from the garden/yard everyday (62%) although some never removed it (1%) or removed it less than once a week (3%). Plastic bags were the most common method used to dispose of faeces from the garden/yard (70%) or when elsewhere (e.g. on a walk) (91%), but a shovel was also commonly used in the garden/yard (42%). Over eighty percent of respondents said that they always picked up any faeces passed by their dog whilst out walking in the street, park area or on a public path, but just over 50% did so when in the countryside (Fig.3.4). A significantly smaller proportion of males reported picking up faeces than females (Table 3.4). In a separate part of the questionnaire, respondents were asked if they wash their hands after picking up faeces, and 96% said they did so 'always' or 'usually'. Fewer reported always or usually washing their hands before eating (85%) or after touching a dog (58%).

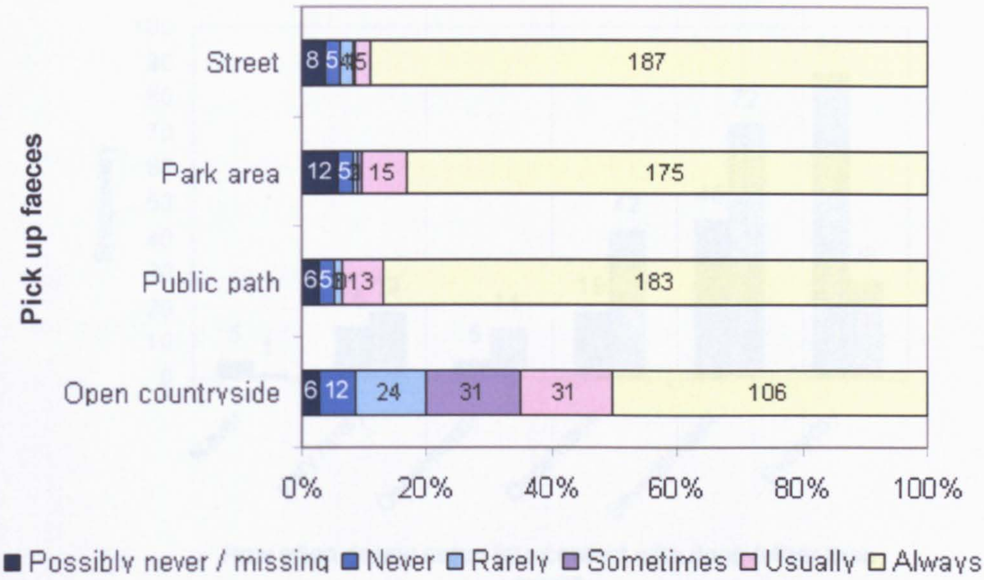


Figure 3.4 Reported frequency of dog owners picking up dog faeces deposited on walks reported by 210 dog owners in Cheshire.

Table 3.4 Frequency of picking up after dog by gender of owner, reported by 116 dog owners in Cheshire.

Area	**Gender owner**	**Frequency of picking up faeces** Never/Rarely/Missing n (%)	Sometimes/Usually/Always n (%)	**P-value**
Street	Male	7 (19%)	30 (81%)	0.11*
	Female	6 (8%)	73 (92%)	
Park	Male	8 (22%)	29 (78%)	0.03*
	Female	6 (8%)	73 (92%)	
Public path	Male	7 (18%)	30 (81%)	0.01*
	Female	3 (4%)	76 (96%)	
Open countryside	Male	15 (41%)	22 (59%)	0.005
	Female	13 (16%)	66 (84%)	

* = Fisher's Exact P-value

3.3.5 Validity of the questionnaire

The questions concerning contact with dogs other than their own had also been repeated in the initial door-step interview (see Chapter 2), which presented the opportunity to compare the interview responses with the self-administered questionnaire responses for those persons who had indicated that the person completing the questionnaire, and the person interviewed at the door were the same (n=176). Comparison of the results are presented in Figs. 3.5 and 3.6.

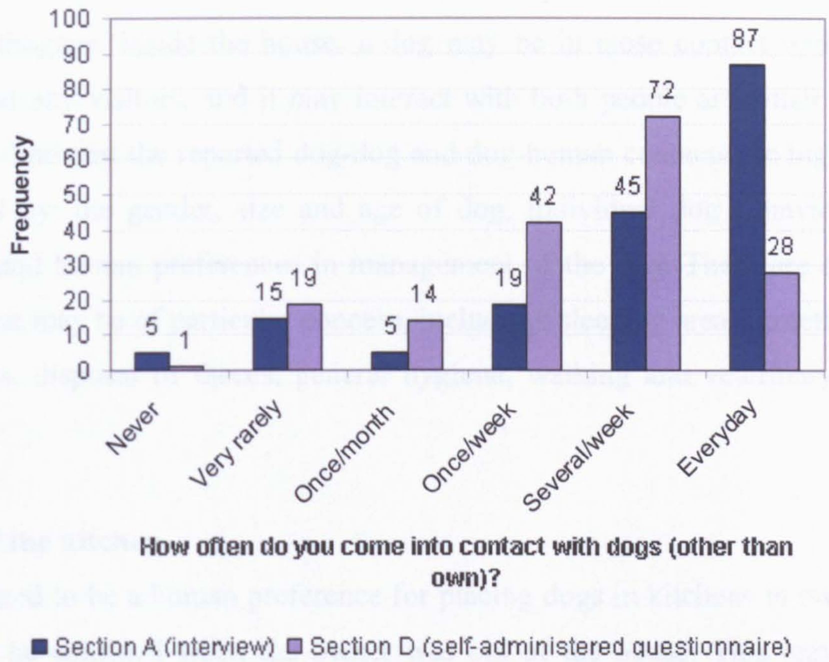


Figure 3.5 Comparison of Section A (interview) and Section D (self administered questionnaire) responses to question on frequency of contact with dogs (other than own).

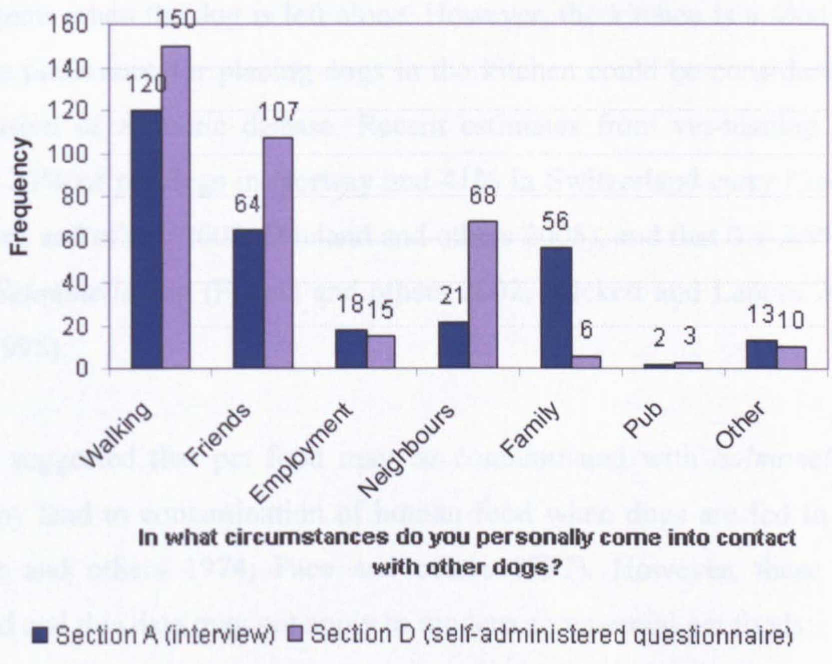


Figure 3.6 Comparison of Section A (interview) and Section D (self administered questionnaire) responses to question on circumstances of contact with dogs (other than own).

3.4 DISCUSSION

In this study we have described an in depth example of many of the common interactions between pet dogs and people that are of interest in a number of contexts including dog bites, public nuisance, animal welfare and social benefits to people. In particular we evaluated those behaviours that may contribute to transmission of zoonotic pathogens. Inside the house, a dog may be in close contact with household members and any visitors, and it may interact with both people and other dogs whilst outside. We find that the reported dog-dog and dog-human contacts are highly variable and affected by: the gender, size and age of dog; individual dog behaviours; human behaviours and human preferences in management of the dog. There are a number of situations that may be of particular concern, including: sleeping areas, greeting, playing, food sources, disposal of faeces, general hygiene, walking and veterinary preventive treatment.

3.4.1 Use of the kitchen

There appeared to be a human preference for placing dogs in kitchens in order to sleep, be fed, and be confined when the owner was out of the house. This may have been partly for hygiene reasons and ease of cleaning, in particular cleaning up urine or faeces, and partly because it restricts access to the rest of the house and valuable household items when the dog is left alone. However, the kitchen is a food preparation area and this preference for placing dogs in the kitchen could be considered a risk for the transmission of zoonotic disease. Recent estimates from vet-visiting populations suggest that 23% of pet dogs in Norway and 41% in Switzerland carry *Campylobacter* spp (Sandberg and others 2002; Wieland and others 2005), and that 0.1-3.5% of healthy dogs carry *Salmonella* spp (Fukata and others 2002; Hackett and Lappin 2003; Weber and others 1995).

It has been suggested that pet food may be contaminated with *Salmonella* spp. and therefore may lead to contamination of human food when dogs are fed in the kitchen (Christopher and others 1974; Pace and others 1977). However, these reports are relatively old and this data may not apply to modern commercial pet foods.

3.4.2 Diet

Most dogs were fed a commercial pet food, and were not deliberately fed raw meat, although a small number of dogs may have contacted raw meat by eating or rolling in carcases. Raw meat can be a source of many zoonotic pathogens such as *Campylobacter* spp. and *Salmonella* spp. (LeJeune and Hancock 2001). A few of the dogs were reported to sometimes eat dog faeces which could also be a source of infection. Eating faeces has previously been reported in only 0.2% of dogs (Beaver 1994) but it is uncertain whether this figure represents ingestion of own faeces only or included that of other dogs and animals. We found a considerably higher prevalence than this in the current study but were unable to identify a reason for this difference.

Many dogs were fed commercial dog treats but it was also common to feed human food tit-bits, with 11% eating them straight off the plate 'sometimes' or 'often'. Our figure is lower than that reported by Heller and others (2007) where 19% were reported to eat from household plates; it may be that their figure included any positive response (including rarely) or this may reflect true differences between the populations studied.

3.4.3 Sleeping and resting areas

Heller and others (2007) reported considerably more dogs sleeping on the bed (41.5%) but similar numbers lying on the sofa in their survey, however their study population was volunteer respondents in town centres/park areas and so different biases are likely to be present when comparing with our study. In addition the scale of possible answers to the question may not be directly comparable. Behaviours such as sleeping on the bed and lying on sofa/lap highlight the often close physical and psychological nature of the dog-human relationship. It has been suggested by some that allowing such behaviours is likely to enhance the hierarchical status of the dog and may be associated with 'alpha' dog behavioural problems or dominance-type aggression for example (Fisher 2001; Guy and others 2001), although others consider this unimportant (Landsberg and others 2003). Substantial numbers of people in the present study reported such behaviours, but few dogs were said to growl at household members therefore not supporting this theory, although these behaviours could be underreported. Jagoe and Serpell (1996) suggested that sleeping in the owner's bedroom was associated with competitive aggression (between dogs or over attention to others), and separation-related urination and defaecation.

The close contact and sharing of beds or furniture could allow the transmission of zoonotic diseases or parasites such as fleas, especially with small and young dogs, which were more likely to lie on laps or furniture. In an ethological study in a small number of family homes, it was observed that small dogs were more likely to jump on a person's lap than large dogs (Smith 1983). MRSA has been reported to be transmitted to a person from an apparently healthy dog that routinely slept in the owners' bed and licked their faces (Manian 2003). It is currently unknown how many healthy pet dogs in the UK are carriers of MRSA but one small study of dogs in a veterinary referral hospital found a prevalence of 9%, even though none were being treated for an MRSA infection (Loeffler and others 2005).

3.4.4 Interaction with household members and visitors

Common behaviours with household members and visitors such as sniffing and licking hands and faces could potentially transfer pathogens and were also indicated as common by Heller and others (2007). Such behaviours, which were more common in young dogs in our study, are often attention-seeking/care soliciting gestures (Scott and Fuller 1965) and indicate the strength of the social bond of dogs with people. Small dogs were also reported to jump up more often than large dogs and this finding has been suggested previously (Smith 1983).

Many games were reported to be played with the dogs, and they may transfer saliva and potential pathogens to the hands, particularly with the popular game of 'fetch'. Previously it has been observed that medium dogs are more likely to play games with their owners whilst walking than large or small dogs (Rooney and others 2000) although these authors found no effects of dog size in a different survey of owners on the games they played with their dogs. Our study asked about each type of game separately and found differences in the type of game played depending on the size of animal. Furthermore, our results did not relate just to games played during walks. Fetch games have previously been reported to be seen more with large dogs whilst walking (Messent 1983), similar to our findings.

Another commonly reported activity that may transfer saliva was the giving of treats (commercial or human food tit-bits) from the hand. A small number of dogs were reported to eat directly from the plate. The majority of people reported that they 'always' or 'usually' washed their hands after touching a dog but this is likely to be an overestimation owing to the owners' expectations of being judged by their answer.

3.4.5 Disposal of faeces

Dog faeces are considered a nuisance as well as a potential health hazard. In addition to bacterial zoonoses, parasitic infections may also be present. For example, most puppies become infected with *Toxocara canis* in the first few weeks of life (Glickman 1990) hence the need for regular de-worming treatment. Leaving faeces in the garden or yard may lead to prolonged exposure for the household members. Open countryside was common dog walking territory but was also the area that persons were least likely to pick up their dog's faeces. Almost all respondents stated that they 'always' or 'usually' washed their hands after picking up faeces (as corroborated by Heller and others, 2007) but this may be impossible in practice because most of the dogs commonly passed faeces whilst out walking. The majority of respondents reported cleaning up after their dog, although previous studies have observed 54-59% of people cleaning up (Webley and Siviter 2000; Wells 2006) whilst self-reporting much higher rates. Our study suggests that male owners may be less likely to pick up after their dog, or alternatively will more readily admit to leaving it, however an observational study has also reported fewer males than females picking up after their dog (Wells 2006).

3.4.6 Dog walking

Walking with a dog has been shown to facilitate social interactions, suggesting potential for psychological, as well as physical, benefits to owners (Messent 1983). There was considerable variation in walking preferences but a substantial number of dogs were walked on regular routes at regular times of days, and could have repeated opportunities for contact with certain other dogs and people. This idea is supported by the fact that most dog owners reported that they noticed the same dogs and owners on their walks. In our study, most dogs were walked twice or once a day, for mostly either 16-30mins or 31mins-1hr, whereas Heller and others (2007) reported a median of 3 walks per day in their survey (range 1-10), but again with a similar 'average' walk of 30 mins. More opportunities for contact on weekends than weekdays were reported in our study. The majority of dogs remained in sight on walks when off lead, suggesting that dogs remain fairly close. It has been reported in a previous study that off lead dogs generally travelled less than 2-5m off trail for fewer than 1-2 minutes (Bekoff and Meaney 1997) though this is likely to vary depending on the environment. Many of the dog owners reported taking their dog in the car or using public transport to walk outside of the immediate local area on a regular basis, providing opportunity for dogs from different areas to mix and increase the risk of disease transmission further afield. Some dogs were regularly taken to friends' or relatives' houses where they may interact with other dogs and people.

Diseases may transmit through and persist in the dog population due to interactions between dogs whilst walking. This study suggests that younger dogs might be considered more at risk than older dogs by performing close contact behaviours such as playfulness, and are less likely to ignore other dogs. There was some evidence that entire males may be more likely to sniff other dogs. Bradshaw and Lea (1992) also observed that when two dogs met the most common interactions seen were inspection of the head and anogenital areas, with males investigating the anogenital area more frequently than females, and they suggested that sex of the dogs (and possibly whether or not it is neutered) affects the type of interactions.

3.4.7 Health and veterinary care

In the past year, the majority of dogs had been taken to a Veterinary Surgeon, who could be an important information source about zoonotic diseases. However, not all of the dogs were regularly taken and so other sources of information need to be considered. Most commonly the owner had acquired a dog from the person who bred it, and thus breeders could also be a source of information for new owners. Just over half of the dogs were reported to have been recently treated for gastrointestinal worms and a similar proportion for fleas. Effective flea and worm treatment is important in respect to welfare of the dog, and considering the close contacts with humans reported.

3.4.8 Response rates and biases

This study attempted to survey all households in a defined geographic area, and it therefore provides a somewhat different, and possibly less biased, view of dog ownership compared to other studies in which dogs were recruited through veterinary practices or by calls for volunteers who would likely be enthusiasts. Not all of the dogs had visited a veterinary surgeon in the past year and a third of dogs had not been vaccinated in the past year; as a result a considerable number of dogs would have been missed if recruitment was from veterinary practices in this area. Bias due to not contacting a household was minimised by visiting at a variety of times of day and days of week, ensuring good contact rates for the initial recruitment of dogs. Previous information introducing the study (leaflets) and incentives to participate combined with the local knowledge of and community links with the local veterinary teaching hospital may have contributed to the very good response rate for both the initial interviews and return of postal questionnaires.

There may have been some bias due to the different interests of people who completed and returned the questionnaire compared to non-respondents, in particular due to the use of incentives. A smaller proportion of three-dog households completed and returned their questionnaires than two-dog and one-dog households; the extra work involved to complete the questionnaires for three dogs may have been a deterrent. More of the owners did not answer the question about toileting in the house than the question about toileting in the garden or on walks, possibly owing to the sensitivity of the subject, and the rates of toileting in the house may therefore be underestimates.

As this study was only in one small, semi-rural community, the results and conclusions that can be drawn are limited to this area and it may not be possible to generalise to the wider UK population. However, the percentage of the population owning a dog was similar (24%) to the 21% reported previously for the UK in 2004 (PFMA 2004), supporting the suggestion that results gained from this study may be indicative of similar populations elsewhere.

3.4.9 Validation of questions

The majority of the questionnaire was not validated and it is possible that owners would respond differently if questioned again. When faced with the scale 'everyday-never', when questioned about contact with dogs other than their own, the respondents tended to be less inclined to indicate the extreme ends on the postal questionnaire than when asked in interview. Regarding circumstances, there were significant differences seen for 'walking', 'friends', 'neighbours' and 'family' ($P<0.001$ for all). When able to see the suggestions on the questionnaire the respondents were more likely to indicate them, probably using them as a prompt. 'Family' was not included as a prompt on the self-administered questionnaire (just calculated from 'other - please specify') and was less likely to be suggested without this prompt. In both cases 'pub' was deduced from the 'other – please specify' category. It is also possible that after completing the questionnaire and arriving at this question the respondents had already been thinking about the subject of dogs for a period of time and therefore had more suggestions of circumstances to offer.

It was not possible to validate these questions for respondents that did not own dogs. It is unknown whether this finding invalidates the conclusions drawn from Chapter 2 about rates of contact with dogs, because it is unknown whether the non dog owning respondents would have also reported differently via a postal questionnaire. It may be that the dog owners are less different from the non dog owners than previously thought, or there may have still have been significant differences between dog-owning and dog-free respondents. Whether the interviewer listens for an answer and ticks an appropriate category, in contrast to the respondent being able to see the possible choices, may cause considerable error, bias and loss of information (Oppenheim 1992) and should be considered in future questionnaire design.

3.4.10 Conclusion

Our results provide considerable previously unrecorded information about dog ownership that may be typical of many communities in the UK and may be relevant to a number of disciplines. In terms of human health, although dogs are not thought to be a major cause of zoonotic infections compared to food sources, they may still be an important risk to consider, especially for immunocompromised persons, the very young and the elderly.

We have measured a number of factors that may facilitate zoonotic disease transmission in the pet dog owning community including: playing, greeting, food sources, sleeping areas, walking, disposal of faeces, veterinary preventive treatment and general hygiene. These studies may be used to inform strategies for targeted intervention for the control of both zoonotic and other infectious diseases in dogs and provide information that may help in quantifying risks associated with dog ownership. Currently the actual level of risk of zoonotic disease is unknown but not likely to be large. Assessment of the actual risks involved, and the nature of any interventions required, will also depend on the nature of the pathogen and its transmission characteristics.

APPENDIX TO CHAPTER THREE

ASSOCIATIONS OF SIZE, AGE AND GENDER OF DOG WITH OTHER VARIABLES

Table 1. Associations between contact behaviours and size of dog reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Toy/Small (n)	Medium (n)	Large/Giant (n)	P-value
Sleeping on bed	Never	39	49	44	0.42$
	Rarely	6	7	6	
	Sometimes	9	8	3	
	Often	7	5	3	
	Always	12	6	5	
Lie on furniture	Never	17	37	45	**<0.001**
	Rarely	10	9	8	
	Sometimes	29	22	16	
	Often	37	26	8	
Lie on a person's lap	Never	9	33	59	**<0.001**
	Rarely	13	21	9	
	Sometimes	26	24	12	
	Often	43	13	2	
Sniffs/nudges with nose visitors	Never	5	5	6	0.78
	Rarely	9	6	4	
	Sometimes	28	32	23	
	Often	48	48	50	
Jumps up at visitors	Never	7	19	33	**<0.001**
	Rarely	11	14	13	
	Sometimes	33	30	21	
	Often	39	28	13	
Licks face of visitors	Never	41	52	45	0.36
	Rarely	14	17	15	
	Sometimes	18	13	15	
	Often	9	5	2	
Licks hands of visitors	Never	30	34	30	0.82
	Rarely	16	17	14	
	Sometimes	27	25	29	
	Often	12	12	6	
Sniffs/nudges with nose household members	Never	3	2	2	0.68$
	Rarely	8	6	2	
	Sometimes	30	26	25	
	Often	52	57	54	
Jumps up at household members	Never	3	17	22	**<0.001**
	Rarely	9	11	19	
	Sometimes	32	29	23	
	Often	49	35	14	
Licks face of household members	Never	25	36	27	0.08
	Rarely	14	20	16	
	Sometimes	23	22	19	
	Often	27	10	15	
Licks hands of household members	Never	18	24	2	0.67
	Rarely	11	15	15	
	Sometimes	34	32	27	
	Often	27	21	16	
Fetch (missing data recoded as never)	Never	24	10	8	**0.01***
	Rarely	10	5	6	
	Sometimes	21	24	31	
	Often	44	56	39	
Tug-of-war	Never	9	16	21	**0.02**
	Rarely	7	18	10	
	Sometimes	35	24	28	
	Often	36	31	24	

$ = 1 or more cells with expected counts less than 5.

* P=0.08 if missing data removed rather than assumed to be "never".

Table 1 (continued). Associations between contact behaviours and size of dog reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Toy/Small (n)	Medium (n)	Large/Giant (n)	P-value
Rough and tumble games	Never	16	23	22	0.33
	Rarely	11	15	14	
	Sometimes	33	36	32	
	Often	26	16	13	
Chase games	Never	16	31	20	0.24
	Rarely	12	13	11	
	Sometimes	29	24	28	
	Often	28	19	18	
Playful with other dogs (missing data recoded as never)	Never	34	22	18	**0.05***
	Rarely	11	21	9	
	Sometimes	29	35	35	
	Often	25	17	22	
Sniffs other dogs	Never	7	4	3	0.75
	Rarely	7	8	3	
	Sometimes	27	32	26	
	Often	48	49	44	
Ignores other dogs	Never	22	22	10	0.14
	Rarely	19	27	25	
	Sometimes	28	26	34	
	Often	12	11	6	
Aggression with other dogs	Never	37	43	38	0.37
	Rarely	17	25	18	
	Sometimes	20	15	15	
	Often	10	4	4	
Walk frequency	< once / week	5	1	0	**0.04$**
	1-sev / week	27	14	14	
	1-2 /day	55	63	54	
	3+/day or other	12	17	16	
Walk length	0-15mins	8	6	2	0.54$
	16-30mins	35	36	29	
	31mins-1hour	43	40	35	
	Over1 hour	9	11	14	

$ = 1 or more cells with expected counts less than 5.

* P=0.13 if missing data removed rather than assumed to be "never".

Table 2. Associations between contact behaviours and age of dog (identified using ordinal logistic regression) reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Mean approx age in years (SD)	Odds ratio (95% CI)[1]	P-value
Sleeping on bed	Never	6.8 (4.0)	1.0 (1.0-1.1)	0.27
	Rarely	6.3 (3.7)		
	Sometimes	7.1 (4.1)		
	Often	6.7 (3.0)		
	Always	5.4 (3.1)		
Lie on furniture	Never	6.7 (3.9)	1.0 (1.0-1.1)	0.65
	Rarely	7.3 (3.7)		
	Sometimes	6.7 (4.4)		
	Often	6.5 (3.7)		
Lie on a person's lap	Never	7.6 (4.1)	1.1 (1.1-1.2)	**<0.001**
	Rarely	7.3 (3.6)		
	Sometimes	6.1 (3.8)		
	Often	5.4 (3.6)		
Sniffs/nudges with nose visitors	Never	6.4 (3.3)	1.0 (0.9-1.0)	0.40
	Rarely	4.8 (4.2)		
	Sometimes	7.0 (4.1)		
	Often	6.8 (3.9)		
Jumps up at visitors	Never	8.7 (3.5)	1.3 (1.2-1.3)	**<0.001**
	Rarely	8.6 (3.6)		
	Sometimes	6.2 (3.7)		
	Often	4.4 (3.3)		
Licks face of visitors	Never	7.6 (3.8)	1.2 (1.1-1.3)	**<0.001**
	Rarely	5.2 (3.5)		
	Sometimes	6.7 (3.9)		
	Often	2.0 (2.0)		
Licks hands of visitors	Never	7.0 (3.6)	1.1 (1.0-1.1)	0.06
	Rarely	7.2 (3.8)		
	Sometimes	6.5 (4.2)		
	Often	5.1 (4.5)		
Sniffs/nudges with nose household members	Never	6.3 (3.7)	1.0 (0.9-1.1)	0.58
	Rarely	6.0 (3.9)		
	Sometimes	6.8 (3.7)		
	Often	6.8 (4.1)		
Jumps up at household members	Never	8.2 (3.3)	1.2 (1.1-1.2)	**<0.001**
	Rarely	8.2 (3.4)		
	Sometimes	6.3 (4.1)		
	Often	5.4 (3.8)		
Licks face of household members	Never	8.0 (3.8)	1.2 (1.1-1.2)	**<0.001**
	Rarely	6.4 (4.0)		
	Sometimes	6.4 (3.6)		
	Often	4.5 (3.6)		
Licks hands of household members	Never	7.2 (3.4)	1.1 (1.0-1.1)	**0.01**
	Rarely	7.1 (4.2)		
	Sometimes	6.7 (4.0)		
	Often	5.5 (4.1)		
Fetch	Never	8.8 (3.6)	1.2 (1.1-1.3)	**<0.001**
	Rarely	8.4 (3.9)		
	Sometimes	7.3 (3.8)		
	Often	5.6 (3.7)		

[1]The odds ratios presented are from Ordinal logistic regression with the lowest category as never; an OR<1 indicates that as age increases the probability of being in the higher categories increases; an OR>1 indicates that as age increases the probability of being in the lower categories increases.

Table 2 (continued). Associations between contact behaviours and age of dog (identified using ordinal logistic regression) reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Mean approx age in years (SD)	Odds ratio (95% CI)[1]	P-value
Tug-of-war	Never	7.6 (3.8)	1.1 (1.1-1.2)	**<0.001**
	Rarely	7.8 (3.4)		
	Sometimes	7.0 (4.1)		
	Often	5.1 (3.5)		
Rough and tumble games	Never	7.5 (4.0)	1.1 (1.1-1.2)	**<0.001**
	Rarely	8.1 (3.8)		
	Sometimes	6.3 (3.5)		
	Often	5.1 (4.0)		
Chase games	Never	8.1 (3.7)	1.2 (1.1-1.2)	**<0.001**
	Rarely	7.5 (4.3)		
	Sometimes	5.7(3.5)		
	Often	5.3 (3.8)		
Playful with other dogs	Never	8.7 (3.9)	1.1 (1.1-1.2)	**0.001**
	Rarely	6.0 (3.4)		
	Sometimes	6.5 (3.8)		
	Often	5.6 (3.6)		
Sniffs other dogs	Never	7.8 (2.2)	1.0 (1.0-1.1)	0.82
	Rarely	6.2 (3.8)		
	Sometimes	6.7 (3.9)		
	Often	6.7 (4.0)		
Ignores other dogs	Never	6.0 (4.5)	0.9 (0.9-1.0)	**0.03**
	Rarely	5.6 (3.8)		
	Sometimes	6.9 (3.4)		
	Often	7.9 (4.0)		
Aggression with other dogs	Never	6.3 (4.0)	0.9 (0.9-1.0)	0.06
	Rarely	6.2 (3.4)		
	Sometimes	7.9 (3.8)		
	Often	6.9 (3.9)		
Walk frequency	< once / week	8.6 (4.1)	1.1 (1.0-1.1)	0.14
	1-sev / week	7.0 (4.2)		
	1-2 /day	6.2 (3.7)		
	3+/day or other	6.5 (3.1)		
Walk length	0-15mins	8.6 (4.1)	1.1 (1.0-1.1)	**0.04**
	16-30mins	7.0 (4.2)		
	31mins-1hour	6.2 (3.7)		
	Over1 hour	6.5 (3.1)		

[1]The odds ratios presented are from Ordinal logistic regression with the lowest category as never; an OR<1 indicates that as age increases the probability of being in the higher categories increases; an OR>1 indicates that as age increases the probability of being in the lower categories increases.

Table 3. Associations between contact behaviours and sex of dog, reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Male (n)	Female (n)	P-value
Sleeping on bed	Never	64	68	0.21
	Rarely	10	9	
	Sometimes	9	12	
	Often	7	8	
	Always	17	6	
Lie on furniture	Never	51	49	0.80
	Rarely	15	12	
	Sometimes	31	36	
	Often	33	38	
Lie on a person's lap	Never	54	48	0.27
	Rarely	15	28	
	Sometimes	30	32	
	Often	28	30	
Sniffs/nudges with nose visitors	Never	8	8	0.95
	Rarely	8	11	
	Sometimes	41	43	
	Often	72	74	
Jumps up at visitors	Never	27	32	0.63
	Rarely	21	17	
	Sometimes	44	40	
	Often	36	44	
Licks face of visitors	Never	72	67	0.16
	Rarely	25	21	
	Sometimes	20	26	
	Often	4	12	
Licks hands of visitors	Never	47	48	0.36
	Rarely	25	22	
	Sometimes	40	41	
	Often	10	20	
Sniffs/nudges with nose household members	Never	4	3	0.53$
	Rarely	7	9	
	Sometimes	45	36	
	Often	76	88	
Jumps up at household members	Never	20	22	0.80
	Rarely	21	19	
	Sometimes	45	39	
	Often	46	52	
Licks face of household members	Never	51	38	0.27
	Rarely	24	26	
	Sometimes	33	31	
	Often	21	31	
Licks hands of household members	Never	37	25	0.26
	Rarely	21	21	
	Sometimes	45	48	
	Often	27	37	
Fetch	Never	14	13	0.17
	Rarely	14	7	
	Sometimes	42	35	
	Often	61	78	
Tug-of-war	Never	20	26	0.51
	Rarely	15	20	
	Sometimes	48	40	
	Often	47	44	

$ = 1 or more cells with expected counts less than 5.

Table 3 (continued). Associations between contact behaviours and sex of dog, reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Male (n)	Female (n)	P-value
Rough and tumble games	Never	31	30	0.82
	Rarely	21	20	
	Sometimes	46	55	
	Often	29	26	
Chase games	Never	35	32	0.63
	Rarely	16	20	
	Sometimes	45	37	
	Often	30	35	
Playful with other dogs	Never	23	22	0.67
	Rarely	20	21	
	Sometimes	45	55	
	Often	35	29	
Sniffs other dogs	Never	7	7	**0.03**
	Rarely	12	6	
	Sometimes	32	54	
	Often	77	64	
Ignores other dogs	Never	35	19	0.08
	Rarely	31	40	
	Sometimes	41	48	
	Often	13	16	
Aggression with other dogs	Never	56	65	0.29
	Rarely	34	27	
	Sometimes	23	27	
	Often	12	6	
Walk frequency	< once / week	3	3	0.61$
	1-sev / week	29	26	
	1-2 /day	79	94	
	3+/day or other	25	20	
Walk length	0-15mins	8	8	0.82
	16-30mins	51	50	
	31mins-1hour	57	61	
	Over1 hour	14	20	

$ = 1 or more cells with expected counts less than 5.

Table 4. Associations between contact behaviours and neutered status of dog, reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Entire (n)	Neutered (n)	P-value
Sleeping on bed	Never	44	84	0.49
	Rarely	7	12	
	Sometimes	4	17	
	Often	5	10	
	Always	10	12	
Lie on furniture	Never	39	58	0.46
	Rarely	7	20	
	Sometimes	22	43	
	Often	22	48	
Lie on a person's lap	Never	30	69	0.35
	Rarely	15	27	
	Sometimes	19	42	
	Often	25	32	
Sniffs/nudges with nose visitors	Never	6	10	0.98
	Rarely	6	13	
	Sometimes	25	52	
	Often	49	95	
Jumps up at visitors	Never	14	45	0.06
	Rarely	9	29	
	Sometimes	33	49	
	Often	31	45	
Licks face of visitors	Never	50	86	0.81
	Rarely	14	31	
	Sometimes	14	31	
	Often	6	9	
Licks hands of visitors	Never	40	53	0.10
	Rarely	16	31	
	Sometimes	21	57	
	Often	7	22	
Sniffs/nudges with nose household members	Never	2	5	0.40$
	Rarely	5	9	
	Sometimes	33	46	
	Often	50	112	
Jumps up at household members	Never	11	31	0.421
	Rarely	11	28	
	Sometimes	32	49	
	Often	32	64	
Licks face of household members	Never	32	55	0.69
	Rarely	13	35	
	Sometimes	21	41	
	Often	19	33	
Licks hands of household members	Never	27	35	0.19
	Rarely	11	29	
	Sometimes	25	64	
	Often	20	44	
Fetch	Never	9	18	0.73
	Rarely	9	11	
	Sometimes	24	52	
	Often	46	90	
Tug-of-war	Never	17	27	0.90
	Rarely	11	23	
	Sometimes	29	58	
	Often	29	61	

$ = 1 or more cells with expected counts less than 5.

Table 4 (continued). Associations between contact behaviours and neutered status of dog, reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Entire (n)	Neutered (n)	P-value
Rough and tumble games	Never	21	39	0.73
	Rarely	13	28	
	Sometimes	33	66	
	Often	22	31	
Chase games	Never	25	40	0.80
	Rarely	10	25	
	Sometimes	29	53	
	Often	23	40	
Playful with other dogs	Never	13	31	0.55
	Rarely	17	23	
	Sometimes	30	68	
	Often	21	42	
Sniffs other dogs	Never	5	9	0.09
	Rarely	8	10	
	Sometimes	19	66	
	Often	51	86	
Ignores other dogs	Never	25	31	0.11
	Rarely	20	50	
	Sometimes	33	55	
	Often	5	22	
Aggression with other dogs	Never	42	75	0.23
	Rarely	23	38	
	Sometimes	13	37	
	Often	3	15	
Walk frequency	< once / week	2	3	0.08$
	1-sev / week	18	36	
	1-2 /day	50	120	
	3+/day or other	22	22	
Walk length	0-15mins	7	9	0.83
	16-30mins	34	66	
	31mins-1hour	40	76	
	Over1 hour	10	23	

$ = 1 or more cells with expected counts less than 5.

Table 5. Associations between contact behaviours and sex/neutered status of dog, reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Entire male (n)	Neutered male (n)	Entire female (n)	Neutered female (n)	P-value
Sleeping on bed	Never	27	34	17	50	0.70$
	Rarely	5	5	2	7	
	Sometimes	2	7	2	10	
	Often	4	3	1	7	
	Always	8	8	2	4	
Lie on furniture	Never	25	24	14	34	0.78$
	Rarely	5	1	2	10	
	Sometimes	15	14	7	29	
	Often	12	20	10	28	
Lie on a person's lap	Never	23	29	7	40	0.34
	Rarely	7	7	8	20	
	Sometimes	12	17	7	25	
	Often	14	13	11	19	
Sniffs/nudges with nose visitors	Never	2	6	4	4	0.25$
	Rarely	2	6	4	7	
	Sometimes	16	22	12	30	
	Often	37	33	12	62	
Jumps up at visitors	Never	10	17	4	28	0.21$
	Rarely	8	13	1	16	
	Sometimes	20	22	13	27	
	Often	17	16	14	29	
Licks face of visitors	Never	32	37	18	49	0.75$
	Rarely	9	15	5	16	
	Sometimes	8	11	6	20	
	Often	3	1	3	8	
Licks hands of visitors	Never	23	22	17	31	0.36$
	Rarely	11	15	5	17	
	Sometimes	15	22	6	35	
	Often	4	6	3	16	
Sniffs/nudges with nose household members	Never	2	2	0	3	-$
	Rarely	1	5	4	4	
	Sometimes	19	24	14	22	
	Often	35	39	15	73	
Jumps up at household members	Never	10	10	1	21	0.34$
	Rarely	7	14	4	14	
	Sometimes	18	24	14	25	
	Often	20	24	12	40	
Licks face of household members	Never	24	25	8	30	0.50
	Rarely	6	16	7	19	
	Sometimes	13	19	8	22	
	Often	12	9	7	24	
Licks hands of household members	Never	20	17	7	18	0.33$
	Rarely	5	14	6	15	
	Sometimes	17	25	8	39	
	Often	12	15	8	29	
Fetch	Never	7	7	2	11	**0.04**$
	Rarely	9	5	0	6	
	Sometimes	19	22	5	30	
	Often	21	37	25	53	
Tug-of-war	Never	11	7	6	20	0.32$
	Rarely	9	6	2	17	
	Sometimes	19	28	10	30	
	Often	16	30	13	31	

$ = 1 or more cells with expected counts less than 5.

Table 5 (continued). Associations between contact behaviours and sex/neutered status of dog, reported by owner questionnaire for 279 dogs in Cheshire.

Covariate		Entire Male (n)	Neutered female (n)	Entire female (n)	Neutered female (n)	P-value
Rough and tumble games	Never	12	18	9	21	0.85
	Rarely	10	11	3	17	
	Sometimes	19	26	14	40	
	Often	16	11	6	20	
Chase games	Never	17	17	8	23	0.63
	Rarely	8	7	2	18	
	Sometimes	18	27	11	26	
	Often	13	15	10	25	
Playful with other dogs	Never	10	12	3	19	0.87$
	Rarely	11	9	6	14	
	Sometimes	18	25	12	43	
	Often	14	20	7	22	
Sniffs other dogs	Never	3	4	2	5	0.11$
	Rarely	7	5	1	5	
	Sometimes	8	24	11	42	
	Often	37	36	14	50	
Ignores other dogs	Never	17	18	6	13	0.18$
	Rarely	12	18	8	32	
	Sometimes	19	21	14	34	
	Often	4	8	1	14	
Aggression with other dogs	Never	26	27	16	48	0.17$
	Rarely	18	16	5	22	
	Sometimes	7	16	6	21	
	Often	2	10	1	5	
Walk frequency	< once / week	1	1	1	2	-$
	1-sev / week	11	17	7	19	
	1-2 /day	32	45	18	75	
	3+/day or other	15	9	7	13	
Walk length	0-15mins	6	2	1	7	0.76$
	16-30mins	22	28	12	38	
	31mins-1hour	23	32	17	44	
	Over1 hour	7	7	3	16	

$ = 1 or more cells with expected counts less than 5.

CHAPTER FOUR

WALKING THE DOG: EXPLORATION OF THE CONTACT NETWORKS BETWEEN DOGS IN A COMMUNITY

This Chapter has been submitted for publication:
C. Westgarth, R.M. Gaskell, G.L. Pinchbeck, J.W.S. Bradshaw, S. Dawson, R.M. Christley. Walking the dog: exploration of the contact networks between dogs in a community. Epidemiology and Infection.

ABSTRACT

This study uses social network analysis to investigate potential contact with respect to disease transmission among 214 dog owning households in a UK community, through their utilisation of public space during walking. We identified a high level of potential contact between dog owning households; most households walked their dogs in only a few areas but a small number visited many. Highly connected households were more likely to have multiple dogs, walk their dogs off lead, and own Working, Pastoral or some terrier types. Similarly, most areas were only visited by a few households but a few were visited by many. We demonstrated high connectivity and potential for disease transmission between dog owning households, with minimum path lengths of two 'steps' (household-area-household, 74%) or four 'steps' (via two areas, 26%). General network structure remained stable when considering time of walking. Targeted removal of highly connected nodes did not serve to fragment the network, as may be postulated from the general network properties of skewed degree distributions, clustering of nodes and short path lengths. However, this study provides some useful indicators of dog and household types where particular efforts could be directed in preventive disease measures.

4.1 INTRODUCTION

Although pet dogs often live singly or in small groups within a household, they also have a social network with other dogs that they meet, most likely on walks. So far, little is known about the structure of social networks for pet dogs. Past work has focused mainly on the ecology of free-roaming dogs (for example Beck 1973; Boitani and others 1995; Meek 1999; Miller and Lago 1990), owned and stray dog populations in rabies areas (for example Kitala and others 2001; Matter and others 2000), or studied the individual behaviours in dog-dog interactions (Bradshaw and Lea 1992). There has been no research into the frequency, extent and nature of contact within a population of owned pet dogs in western society. However such contacts are potentially important for a number of reasons, including both the spread of disease within the dog population, and the possible spread of zoonotic disease from dogs to humans.

Many factors - essentially host and pathogen characteristics, and environment - influence disease transmission, but clearly the opportunities for contact, and the nature of the contacts between hosts will play a major role. In pet dogs, this may relate not only to the individual behaviour of the dog, but the management of the dog by the owners, both within and outside the home. We have previously carried out a community-based questionnaire study which examined dog-dog and dog-human interactions in terms of management and behaviour, mainly within the household (Chapter 3). Data was also obtained on the walking patterns of owners and dogs, outside the home. In the present study, we have examined this data using social network analysis in order to investigate potential disease transmission within this dog population. Whilst we did not measure actual physical contact between dogs, the information gained provides us with an opportunity to assess potential contacts through dogs being walked in the same areas and in the same time periods. Dogs utilising shared time and space could also contact pathogens indirectly through, for example, investigation of urine or faeces.

Although dogs have not yet been studied in this way, social network analysis has been used in order to investigate a number of other species for areas of potential contact between individuals in relation to infectious disease transmission (Christley and French 2003; Corner and others 2003; Klovdahl and others 1994; Robinson and Christley 2007; Robinson and others 2007). This approach, which is relatively novel in veterinary studies, enables consideration of the patterns in which individuals are linked in small groups and as part of a larger network (Friedman and Aral 2001). Each individual or unit of study is classed as a 'node' and connected to other nodes through 'ties'. In the case of infectious disease these connections can be a risk-potential linkage between two individuals, where infection could be spread if an infectious agent was present (Friedman and Aral 2001). Most studies that use network analysis utilise one-mode data, involving contact between a single class of nodes (Christley and French 2003; Corner and others 2003; Klovdahl and others 1994; Lusseau 2003). Here we use both one and two-mode network approaches, the latter linking the two different node sets of walking areas and dog owning households, thus minimising information loss (Borgatti and Everett 1997). Understanding of such contact networks provides insight into transmission dynamics and may aid identification of targets for intervention and control (Albert and others 2000; Bansal and others 2007; Shirley and Rushton 2005a, b).

4.2 METHODS

4.2.1 Network data collection

A census door-step interview of 1278 households in a community in Cheshire, UK (Chapter 2) identified 266 dog owning households of which 260 were subsequently recruited into a questionnaire study of owner and dog behaviour and general management (Chapter 3). At the time of data collection, study participants were also provided with a map of the local area on which to mark on any regular routes used for dog walks. For data analysis in the present study, the map was divided into 768 square grids (each represents an area 125m by 125m) and each grid area that was entered by a household during their dog walks was recorded. The subsequent two-mode network generated consisted of households linked to grid areas. This was then further converted to a one-mode network of households that contact each other via common walking areas.

It could be argued that dogs that are walked through street areas may be more likely to be on lead and possibly less likely to physically interact even if they are walked through the same place at the same time, unless owners stop to talk to each other or allow their dogs to interact. For this reason, the map was also analysed for areas of park/field/public footpath, termed 'green areas', where the dogs may have been more likely to be off lead and free to interact if they come across each other. These varied in size from small parks to long tracks or sections of a disused railway line which is now a country park, where common routes taken by the walkers could be identified. Eighteen such areas were identified; the smallest was contained in one grid area, the largest in 23 grids. A second two-mode network using households linked to green areas was constructed.

4.2.2 Network analysis

Network characteristics calculated include: degree of a node, defined as the number of ties incident upon that node (e.g. number of households walking in an area); the density of a network, comparing the numbers of ties present to the theoretical maximum number of ties; geodesic distance, as a measure of the minimum path length, i.e. shortest number of steps to travel between two nodes (e.g. two households), and the average clustering coefficient, which is the average probability that two neighbours of a given node are also neighbours of each other. For further explanation of network terminology, see (16, 22-24). The analysis of 2-mode data presents challenges to the standard methods of analysing network data, in particular with respect to geodesic distance and normalising the degree, as not all nodes have the possibility of connecting to each other, but approaches have been described to deal with this (Borgatti and Everett 1997).

For each household, the number of different grid areas visited (two-mode household degree) was analysed for associations with other data using Kruskal Wallis tests in Minitab (Minitab.Inc 2005) as the data did not follow a normal distribution. These included dog types (UK Kennel Club breed type, size, age, sex, neuter status), household types (number of dogs, number of people, age of people, occupations), walk frequency, walk length, whether they regularly walk in the same place or have varied walks, travel outside of the local area for walks, walking with friends or allowing the dog off lead (as presented in Chapter 3). The same analyses were also performed for the number of households contactable through common grid areas (one-mode household degree).

In order to investigate the temporal effect of time of walk on network structure, the 'green areas' network was also analysed following subdivision according to the reported time of walking (categorised as 6-9am, 9am-12pm, 12-3pm, 3-6pm, 6-9pm and 9pm-midnight). Some households were categorised as 'varied' if they did not walk at a regular time, and these were evaluated within their own network.

Excel (Microsoft 2003) and Minitab (Minitab.Inc 2005) were used to graphically represent data. Clustering of the dog walking areas used was examined using filled contour maps in R (Crawley 2007; R Development Core Team 2006) (Fig.4.8a). The social network analysis software UCINET and Netdraw (Borgatti 2002) were used to visualise the networks. Network statistics such as density, and node characteristics such as geodesic distance and normalised degrees were calculated initially in UCINET and then adjusted using methods developed specifically for two-mode networks as appropriate (Borgatti and Everett 1997).

4.3 RESULTS

4.3.1 Response rates

Of the 1278 households initially surveyed, 260 (owning 327 dogs) were recruited into the questionnaire study. In total, marked maps were provided from 214 of the 224 households (96%) that returned the questionnaire (i.e. 82% of all dog owning households recruited).

4.3.2 Network using grid areas

For each household, the grid areas used for dog walking were recorded and used to create a two-mode network, in which the first mode were the grid areas and the second mode the dog owning households (Fig.4.1). In total, 524 of the potential 768 grid areas were utilised for dog walking and there was a high level of connectivity between the nodes.

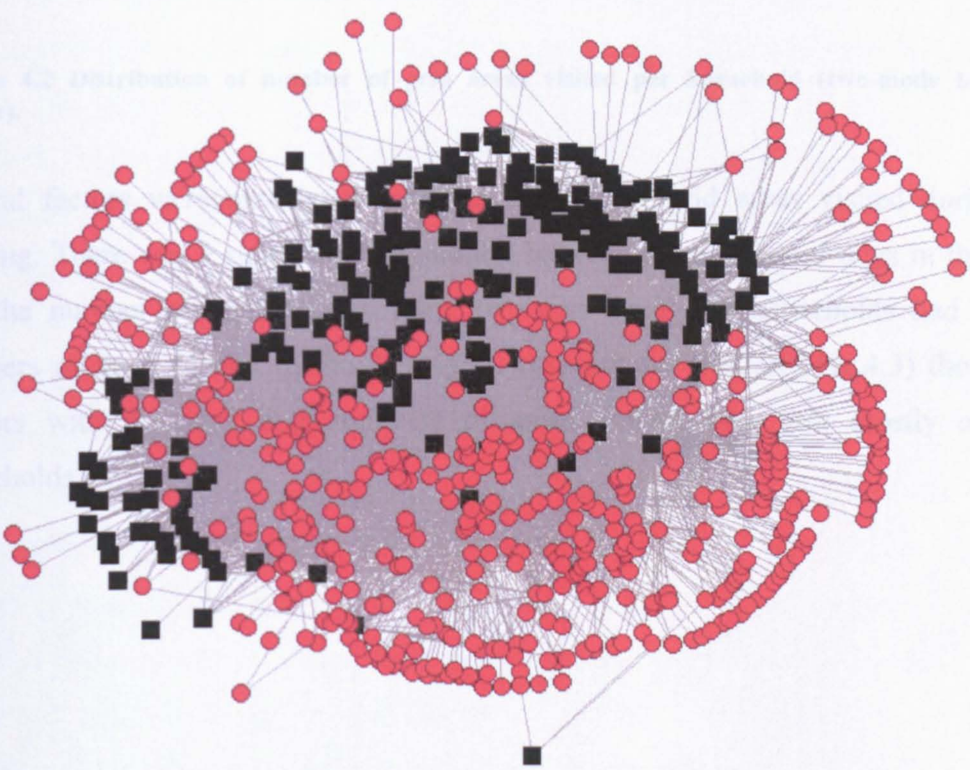


Figure 4.1 Two mode network of 214 dog owning households (red circles) and areas reported to walk through on a regular basis (black squares, n=524). Multi-dimensional scaling plot.

Household degree (two-mode)

Households reported utilising between 1 and 258 grid areas with a median of 25. In network terms, this is defined as the household degree. These data were highly skewed, with most households reporting visiting only a few areas but a few households reporting large numbers (Fig.4.2).

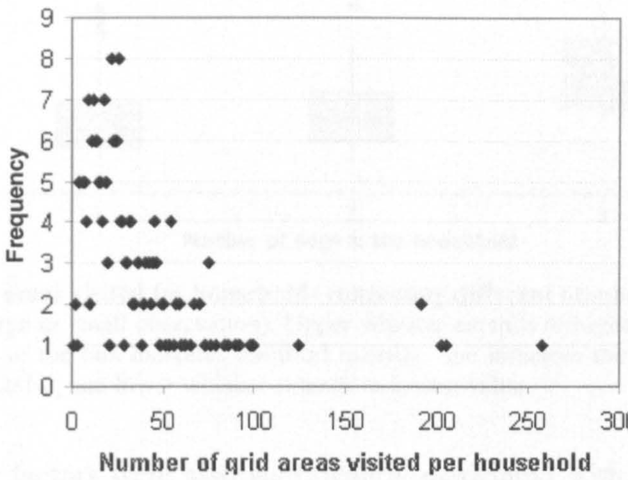


Figure 4.2 Distribution of number of grid areas visited per household (two-mode household degree).

Several factors were associated with the number of grid areas visited during dog walking. There was a significant association between the number of dogs in the house and the number of areas visited: one, two and three dog households had median numbers of areas visited of 23, 31 and 50 respectively (P=0.01, Fig.4.3) though the outliers with the very high numbers of areas visited were still mostly one dog households.

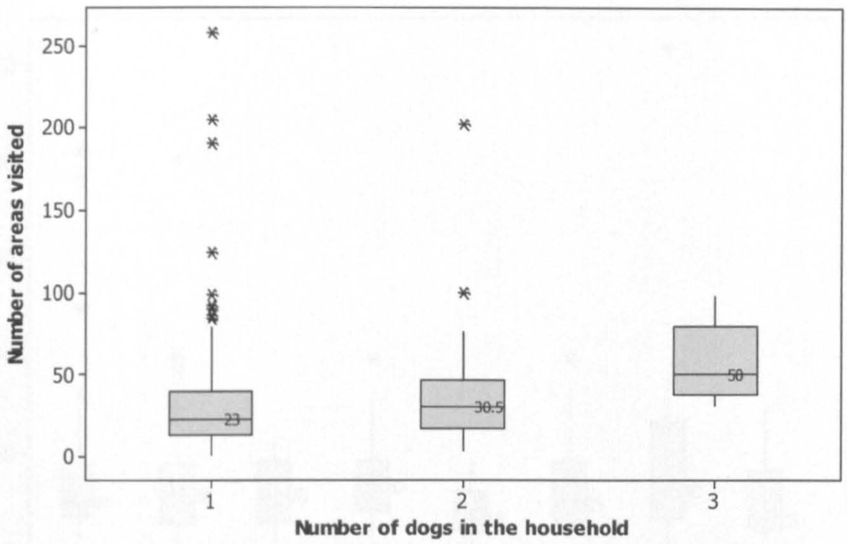


Figure 4.3 Number of areas visited for households containing different numbers of dogs (n=214). *=outlier (unusually large or small observation). Upper whisker extends to highest data value within the upper limit (75%), top of the box indicates the third quartile, line indicates the median, bottom of box indicates first quartile (25%), and lower whisker extends to lowest value.

A number of other factors were also significantly associated with the number of grid areas through which households reported walking. Dogs that visited higher numbers of areas spent more time off the lead (P=0.001), had longer average walk lengths (P<0.001), and had varied walks rather than walking in the same place (P<0.001). The dog owners that walked in many areas also reported higher frequencies of taking the dog outside of the local area (i.e. outside the area illustrated in the map provided) to be walked (P=0.01). For UK Kennel Club breed types there were differences approaching significance (P=0.06), with Working, Pastoral, and Unrecognised categories (Unrecognised including Jack Russell and Patterdale terriers) having higher median number of areas visited than Gundogs, Hounds, Crossbreeds, Toy, Utilities and Terriers (particularly low) (Fig.4.4). There was no evidence for a significant association between number of areas visited and general type (known breed, cross or unknown), size, sex, neutered status or age of dog. There was also no evidence for a significant effect of: number of people in the household, ages, or occupations of the people in the household, frequency of walks or commonly walking with a group of friends.

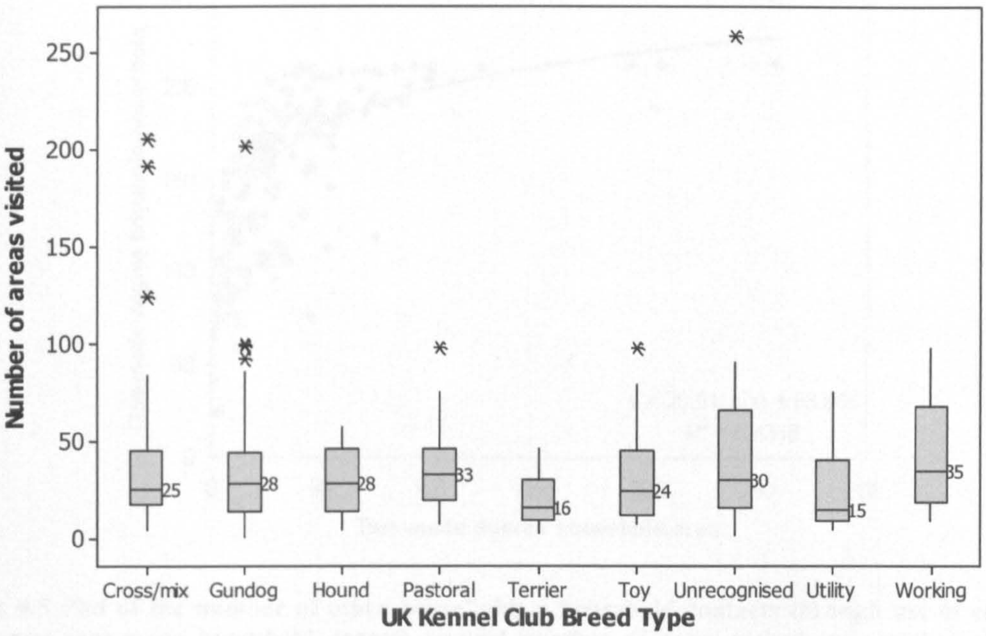


Figure 4.4 Number of areas visited for each dog type (UK Kennel Club Categories) (n=267).

Geodesic distance (path length)

In the entire grid areas network, households could contact another household through two 'steps' (74%) or four 'steps' (26%). A two-step is defined as one-step to area, one-step to household i.e. two households walking in a common area. Therefore households were contactable with all other households in the grid areas network either directly or through one of the households that they walk in the same area with.

Household degree (one-mode)

When the network was converted to one-mode, it was apparent that there was a relationship between the number of grid areas visited and the number of other households that a household may contact through these areas (Fig.4.5). The two-mode degree increased approximately logarithmically with one-mode degree.

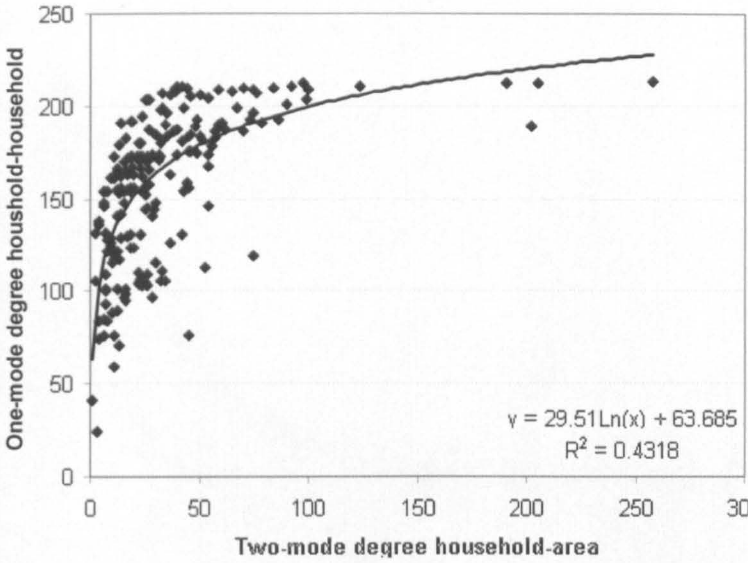


Figure 4.5 Plot of the number of other households a household contacts through use of common grid areas (one-mode household degree) against number of areas visited (two-mode household degree).

Similar significant associations of number of households contacted were found as to number of areas visited (number of dogs, walk length, off lead allowances, and having varied walks, although not travel to walk outside of the area), but the relationship with UK Kennel Club breed type was now highly significant (P=0.01); there was also a slight change in rankings (highest to lowest: Working, Unrecognised, Pastoral, Crossbreed, Toy, Utility, Hound, Gundog, Terrier).

The relationship between the strength of the tie and the size of the network was investigated by sequential deletion of ties, starting with ties with the lowest tie strength (value 1);as the value of the ties increased, the number of connected nodes decreased through the formation of isolated nodes, but a single large connected component remained rather than sub-division into smaller networks (Fig.4.6). Similarly, sequential, targeted deletion of nodes, starting with the highest degree, demonstrated that the redundancy of links in the network was such that it took until removal of the 164^{th} node (i.e.77% of households) before any subdivision of the network was observed; and this only served to isolate one node from the large component.

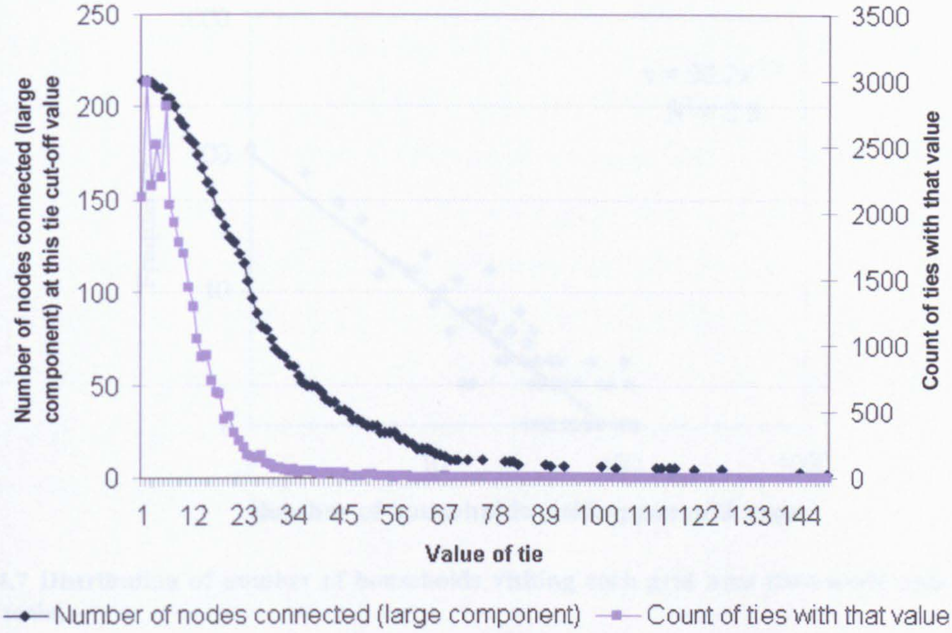


Figure 4.6 Plots of the large component size (number of connected nodes) at different tie strengths between the nodes, and count of node pairs connected at each tie strength, for the one-mode network of contact between households through use of common grid areas.

Clustering coefficient

The one-mode network of household-household contacts had an average clustering coefficient of 0.88, demonstrating a high level of clustering between the nodes. This value remained high when various cut-off levels (from 10 to 60) in the strength of the ties between nodes were examined (for example only those households connected by walking in 50 or more common areas).

Grid area degree (two-mode)

For each grid area the number of households that reported to walk through them was recorded and again was highly skewed (Fig.4.7). Indeed, there was evidence that this approximated a power-law distribution. Most areas were visited by a few households but a few areas were visited by more than half of the households; the area degree ranged from 1 to 124 (excluding areas not visited at all).

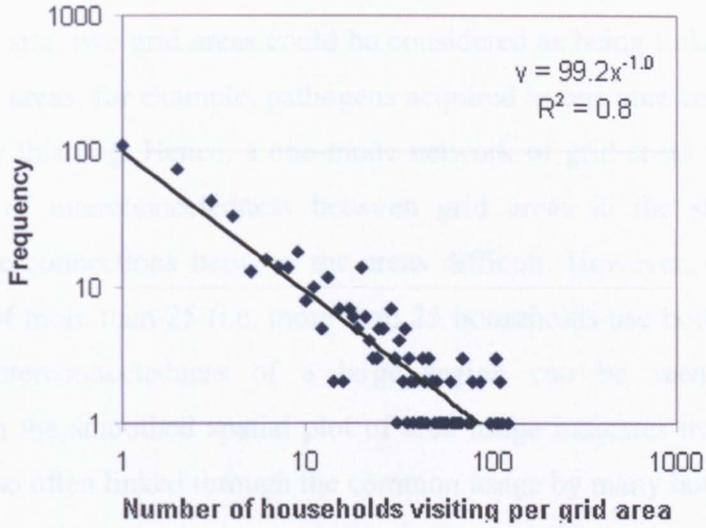


Figure 4.7 Distribution of number of households visiting each grid area (two-mode area degree). (log-log scale)

There was spatial clustering of grid areas used by many households (Fig.4.8a). A nature reserve, a country park path and a road (leading to the nature reserve) were amongst the most popular walking areas.

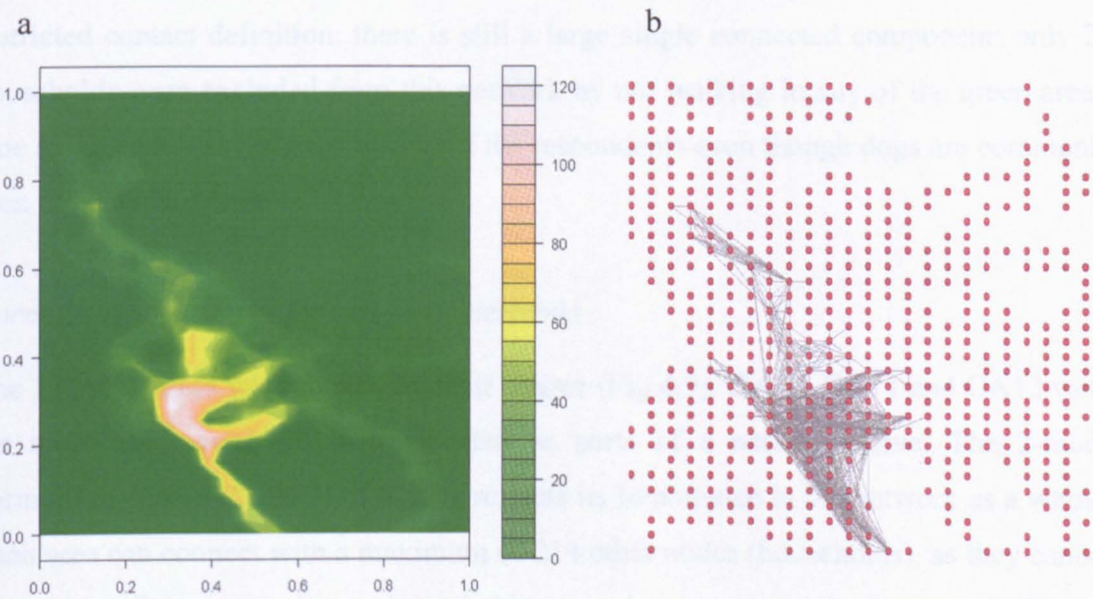


Figure 4.8 Areas plotted by coordinates.
a). Smoothed spatial plot. Scale=numbers of households walking through that area (degree). White=high, green=low.
b) Links shown between areas with ties of strength over 25 (over 25 common households walking through them both).

Grid area degree (one-mode)

Within the study site, two grid areas could be considered as being linked if at least one dog utilised both areas; for example, pathogens acquired in one area could be carried to the other area by this dog. Hence, a one-mode network of grid areas was constructed. The high level of interconnectedness between grid areas in the study site makes illustration of the connections between the areas difficult. However, even when links with a strength of more than 25 (i.e. more than 25 households use both areas) only are included, the interconnectedness of a large region can be seen (Figure 4.8b). Comparison with the smoothed spatial plot of area usage indicates that the frequently used areas are also often linked through the common usage by many households.

4.3.3 Network using 'green areas'

One hundred and ninety-three households used at least one green area. Analysis of the network using green areas (Fig.4.10a) suggested there was a tendency towards the formation of two clusters of walking areas and three clusters of households. One household cluster utilised both green area clusters, whilst the remaining household clusters each tended to only use one or other of the green area clusters. Even using this restricted contact definition, there is still a large single connected component; only 21 households were excluded from this network by not walking in any of the green areas. One small park was not used by any of the respondents even though dogs are commonly seen to be walked here.

Normalising the degree for two-mode networks

The 17 green areas were ranked by their degree (Fig.4.9): GA10, GA11 and GA12 were the most used areas, all being located as parts of a nature reserve. The 2-mode normalised degree (2MND) of a node reflects its importance in the network as a whole. Each area can connect with a maximum of 214 other nodes (households), as they cannot connect to other areas, whereas households can only connect to a maximum of 17 areas. In order to directly compare the degree of households and areas it is necessary to perform 'normalisation' to a maximum score of 100. The maximum 2MND was 94, for a household that had the possibility of walking in almost all of the areas mentioned. In all, five of the households were higher ranked than the most popular area and so relatively linked to more other possible nodes than any of the areas; the lower rankings in the 2MND were mixed between households and areas (data not shown).

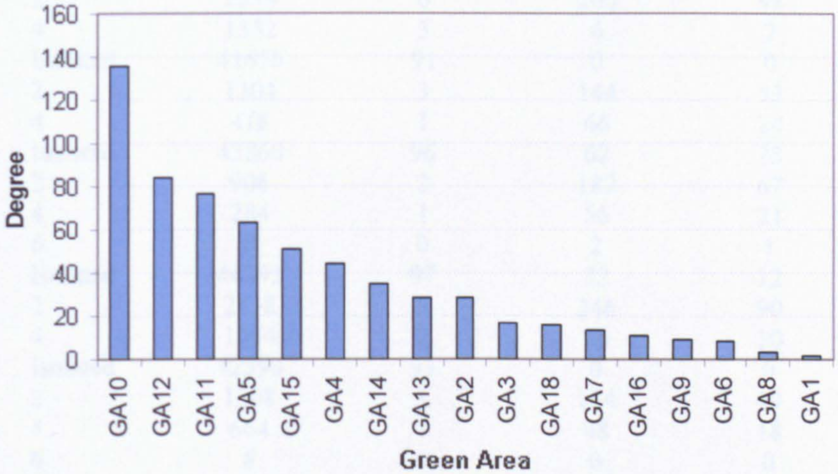


Figure 4.9 Degrees of green areas.

Geodesic distance (path length)

The geodesic distances between the nodes are shown in Table 4.1. In the entire green areas network, households could commonly contact another household through two 'steps' (56%) or four 'steps' (25%), compared to 74% and 26% respectively in the grid areas network. Therefore households are contactable with all other households in the grid areas network either directly or through one of the households that they walk in the same area with; whereas in the green areas network 19% of all household pairs were isolated from each other.

Density

The density of the green areas network was 0.34 (34% of the possible ties are present).

Table 4.1 Geodesic distance (minimum path length) and density for green areas networks.

Time	Distance	Household pairs		Area pairs		Density
		number	%	number	%	
All times	2	25516	56	266	98	0.344
	4	11540	25	6	2	
	Isolated	8526	19	0	0	
6-9am	2	2574	6	266	98	0.114
	4	1332	3	6	2	
	Isolated	41676	91	0	0	
9am-12pm	2	1304	3	144	53	0.076
	4	418	1	66	24	
	Isolated	43860	96	62	23	
12-3pm	2	906	2	182	67	0.071
	4	284	1	56	21	
	6	0	0	2	1	
	Isolated	44392	97	32	12	
3-6pm	2	2138	5	246	90	0.103
	4	1054	2	26	10	
	Isolated	42390	93	0	0	
6-9pm	2	1308	3	134	49	0.077
	4	664	1	48	18	
	6	8	0	0	0	
	Isolated	43602	96	90	33	
9pm-12am	2	312	1	240	88	0.039
	4	150	0	0	0	
	Isolated	45120	99	32	12	
Varied times	2	2260	5	238	88	0.102
	4	820	2	34	13	
	Isolated	42502	93	0	0	
Combined times network	2	9152	20	4930	35	0.083
	4	12432	27	4120	29	
	6	128	0	152	1	
	Isolated	23870	52	4840	34	

The total number of household pairs and area pairs is 214x213=45582 and 17x16=272, respectively, for all green areas networks except the combined times network. The combined times network is based on 214x213=45582 households pairs and 119x118=14042 time-area pairs (i.e. 17 areas x 7 time periods).

4.3.4 Networks by time

Knowledge of the general time period that each household walked in allowed the network to be further sub-divided into smaller networks of dogs that are walked in the same place at approximately the same time of day (Fig.4.10). Fifty-six households did not walk at a particular time of the day but at varied times and were, for analysis purposes, separated into their own network even though they may be present at various times in the areas that they choose to walk in. Overall, subdivision of the networks by time suggested that the basic structure was stable across various times of the day.

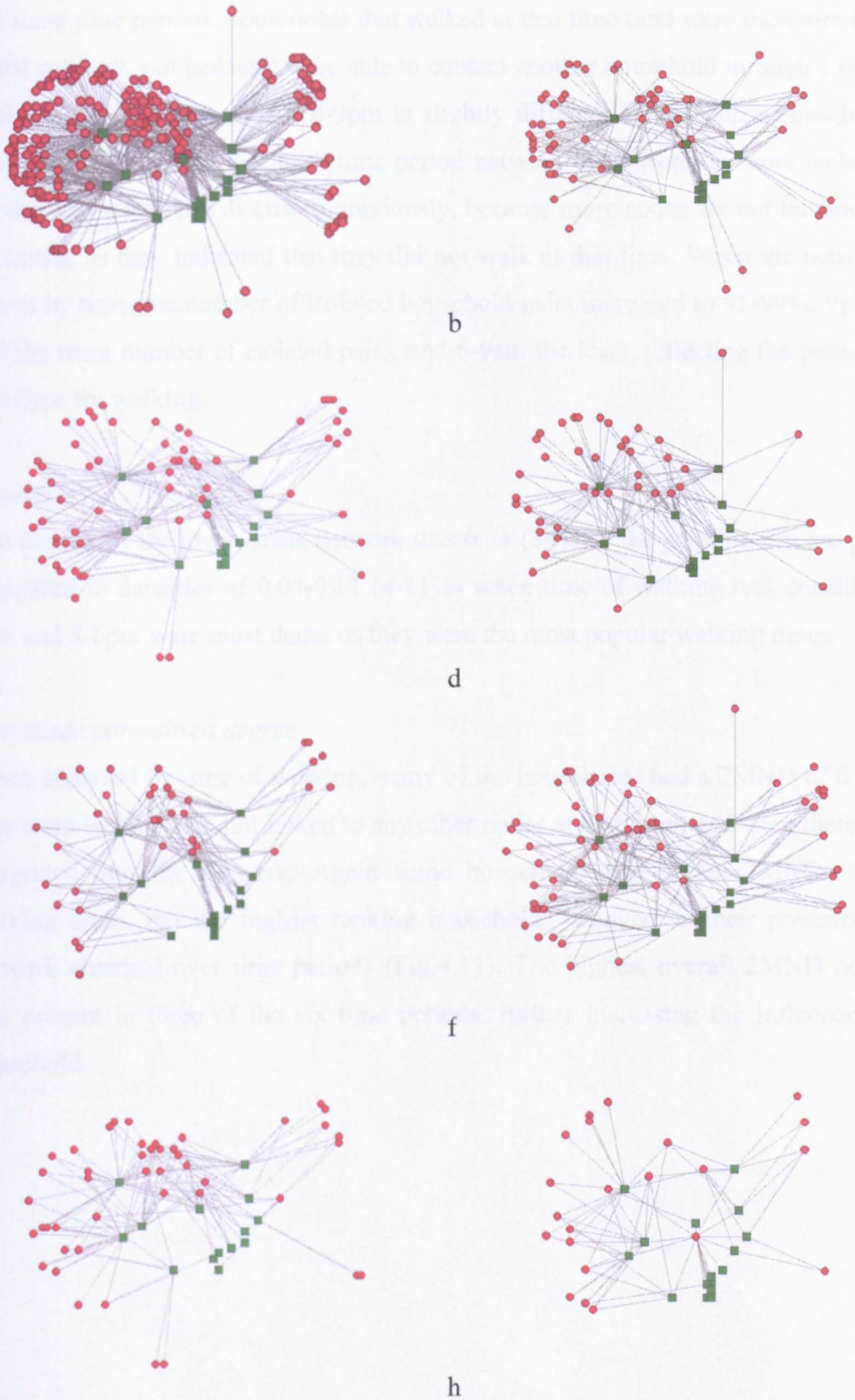


Figure 4.10 Green areas networks.
a) Two mode network for Green Areas at all times (number of households = 193). Multi-dimensional scaling plot. Circles=households and green squares=groups of walking areas (set of paths or a park) termed green areas. b) varied times (n=64), c) 6-9am (n=68), d) 9am-12pm (n=48), e) 12-3pm (n=35), f) 3-6pm (n=61), g) 6-9pm (n=50), h) 9pm-12am (n=23). Fixed node coordinates from a).

Geodesic distance (path length)

For most time periods, households that walked at that time (and were therefore included in the network, not isolated) were able to contact another household through 2 or 4 steps (Table 4.1). The network for 6-9pm is slightly different in that some households are separated by six steps. For each time period network there were far more isolates than for the whole network discussed previously, because more nodes are not included in the networks, as they indicated that they did not walk at that time. When the network was subset by time, the number of isolated household pairs increased to 91-99%; 9pm-12am had the most number of isolated pairs, and 6-9am the least, reflecting the popularity of that time for walking.

Density

The density of the green areas network was 0.34 (34% of the possible ties are present), compared to densities of 0.04-0.11 (4-11%) when time of walking was considered; 6-9am and 3-6pm were most dense as they were the most popular walking times.

Two-mode normalised degree

When analysed by time of walking, many of the households had a 2MND of 0 because they were isolates (i.e. not linked to any other nodes at that time) and were therefore not integrated into the network. Again some households had higher 2MNDs than the walking areas, but the highest ranking households changed as their presence in the network changed over time periods (Fig.4.11). The highest overall 2MND node (94) was present in three of the six time periods, further increasing the influence of this household.

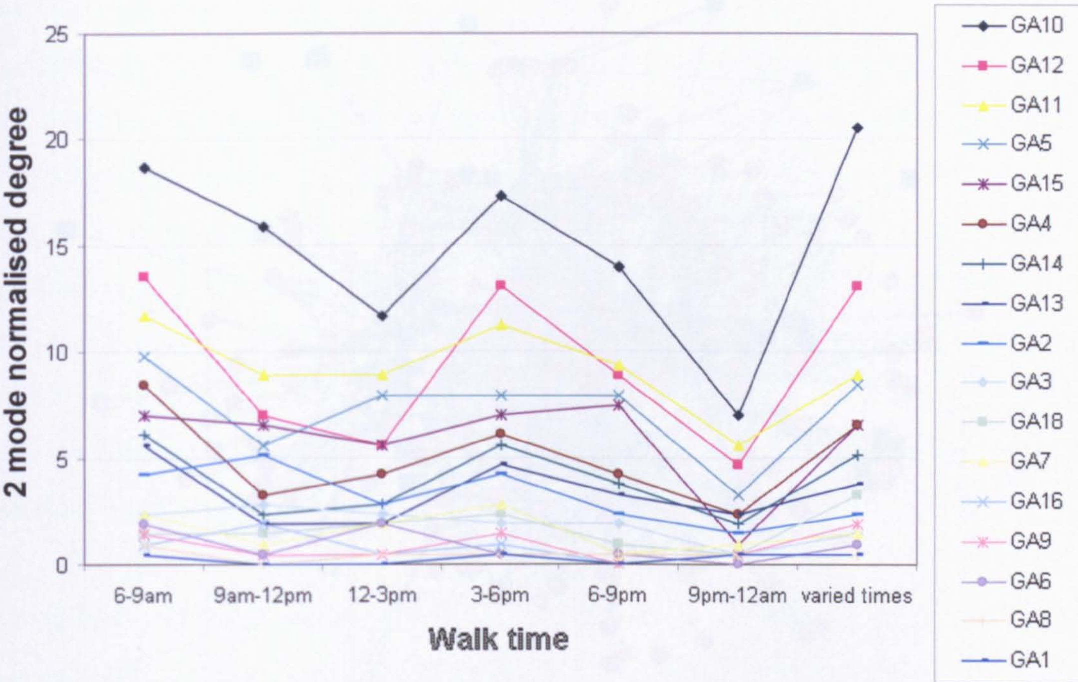


Figure 4.11 Two-mode normalised degrees for each green area at different walking times.

Combining separate times networks into one

The individual times networks were then combined into one large network using one set of household nodes (n=214) and a set of area nodes for each time period (n=7x17=119). The sub-networks produced at different time periods are connected by the dogs that are walked more than once a day; these households are positioned in the middle of this larger network (Fig.4.12). The density of this network is considerably less than if time of walking is ignored (Table 4.1; 0.08 compared to 0.34) because of the distancing effect of walking at different times.

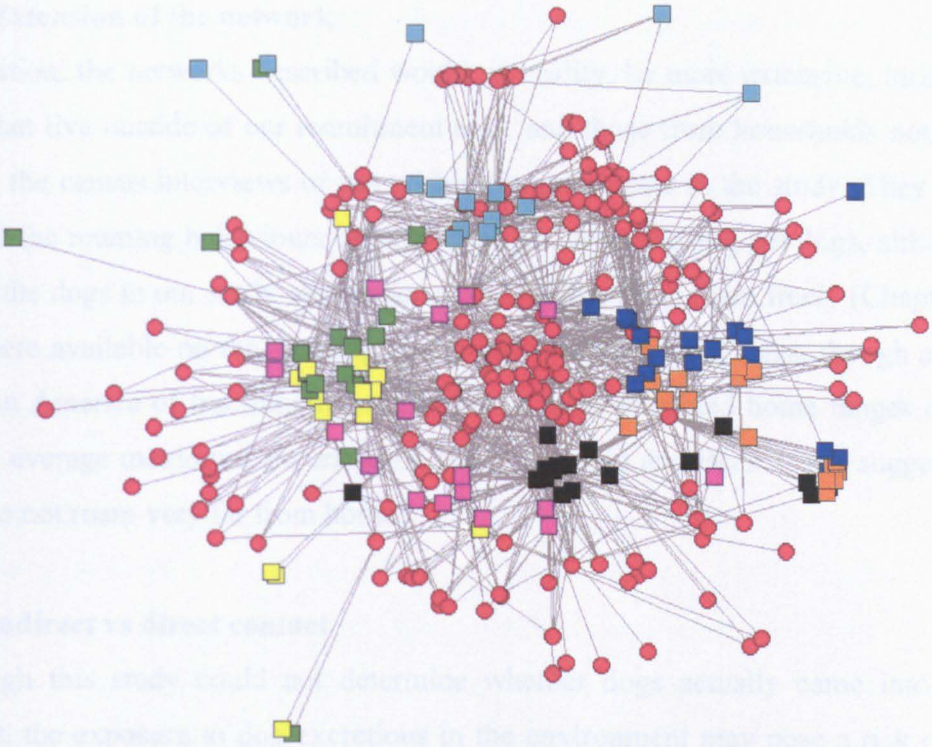


Figure 4.12 Network representing the combination of all time periods. Each green area (squares) is represented 7 times (each time period and varied times, n=119), each square node of the same colour represents the same green area at different times of the day; each household (red circles) only appears once (n=193).

4.4 DISCUSSION

4.4.1 General connectivity of the network

Many dog owners would agree that it is not uncommon for their pet dog to contact other dogs on their daily walks. However, using network analysis of dog walking patterns in a small community, this study has demonstrated that a surprisingly high level of overall potential contact exists between the dogs through their utilisation of public space. All household pairs in the grid areas network, or 81% in the green areas network, could contact each other, either directly or via walking with one other household. It must be noted that, in reality, the dogs may not be daily traversing all of the walks reported for that household, but if these walks are regular and consistent (as requested) then there is a good chance of repeated opportunities for contact between dogs, in particular given the strength of the ties between households demonstrated. Even if only a proportion of these potential events resulted in actual contact, there would likely remain considerable connectivity given the level of opportunity demonstrated here.

4.4.2 Extension of the network

In addition, the networks described would, in reality, be more extensive, incorporating dogs that live outside of our recruitment area, and those from households not available during the census interviews or not wishing to participate in the study. They may also include the roaming behaviours of stray dogs and free-roaming pet dogs, although only 1% of the dogs in our study were reported to be allowed to roam freely (Chapter 3). No data were available on the roaming ranges and routes of these dogs, though a previous study in America of free-ranging owned urban dogs estimated home ranges of 0.1km^2 and an average maximum excursion of 165.1m (Rubin and Beck 1982) suggesting that dogs do not roam very far from home.

4.4.3 Indirect vs direct contact

Although this study could not determine whether dogs actually came into physical contact, the exposure to dog excretions in the environment may pose a risk of disease transmission. For example, the enteric pathogen canine coronavirus can survive warm temperatures for several days but seems to prefer colder temperatures and therefore may survive longer during winter months (Tennant and others 1994). Campylobacters also manage to persist in the environment despite lacking many of the usual bacterial survival mechanisms (Murphy and others 2006). Feline parvovirus shed in faeces can survive in the environment for several months (Ikeda and others 2002) and it is likely that canine parvovirus is the same.

Although indirect contact may be sufficient in some cases for disease transmission, it is probable that direct physical contact is of higher risk, for example in the transmission of upper respiratory tract diseases by contact with infectious discharges or by aerosol (Greene 2006). Whether dogs actually physically contact each other if they are present in an area at the same time will also depend on their individual behaviour; avoidance behaviours may act to reduce the number of contacts, and play, investigative or aggressive behaviours may increase them. It is not currently known how likely dogs are to contact each other given the opportunity, but due to the increased emphasis over recent years on the importance of socialisation (Hunthausen and Seksel 2002), it is likely that many dogs do choose to interact and owners may encourage this. Some of the dogs may be kept on a lead all of the time, however this does not necessarily prevent them from physically interacting.

4.4.4 Network characteristics in relation to disease transmission and intervention strategies

Our networks demonstrated short path lengths, clustering of nodes, and some skewed degree distributions and it has been shown that rapid disease spread can occur through networks with these properties (Shirley and Rushton 2005a; Watts and Strogatz 1998). Many real networks have been found to have short path lengths and clustering of nodes, leading to the term 'small world' networks (Watts and Strogatz 1998). Such networks are claimed to be robust and tolerant to random removal of nodes, as most nodes are not highly connected. In contrast, targeted removal of the most highly connected nodes is reported to dramatically change the path structure between the remaining nodes, decreasing their ability to communicate across the network (Albert and others 2000). How such theoretical studies translate to empirical studies and practical applications is not clear, however, there are important implications for disease prevention. In theory, highly connected dogs could be identified and 'removed' from the infectious disease network, for example through targeted vaccination or stopped from being walked during a critical disease (epidemic) period. However, the high overall connectivity of our network meant that experimental targeted removal of nodes in this manner did not have the effect described above.

It has been suggested that many one-mode networks follow a power-law, termed 'scale-free', degree distribution (Barabási and Albert 1999). Whilst some authors have suggested this may be due to universal organisational principles of nature (Barabasi and Albert 1999), this has recently been disputed (Keller 2005; May 2006). Our distribution of the number of households visiting each area, does suggest that when extrapolated to larger regions, there may be areas that are visited by an extremely large number of dog owning households. However, although unobserved in our sample, a cut-off is likely to occur in this distribution, due to practical constraints on the number of households that can use a particular area.

Common features of areas with high degrees included park or recreation space, or the access to such spaces. Such areas represent areas of high risk potential for the transmission of disease and could be targeted for restricting access should disease outbreaks occur. However, it is difficult to predict the effect of "closure" of specific highly used areas; walking may become more widely disseminated throughout the community (perhaps reducing contact between dogs) or may simply tend to relocate to a few other locations, or even on the street. Detailed knowledge of space utilisation by dog owners may also facilitate placement of dog waste disposal bins and other public health measures.

Analysis of the number of areas visited by each household also suggested a skewed distribution of dog walking distance and variability of routes. Most households walked dogs in only a few areas, but a small number visited many areas. However this did not appear to follow a power-law distribution, possibly because lifestyle constraints acting on a dog owner are also likely to influence the number of areas he/she can practically walk in. In addition, as the number of areas visited rose, there was a limit on the number of extra households contacted. However this may be due to the 'invisibility' of other dogs that walked in those areas but lived outside of our questionnaire recruitment area.

The dogs in the higher degree households may be important for assisting the transmission of disease through the network, as they have the potential to contact more other dogs. The households that walked in many areas were also identified from the questionnaire as those who walked their dogs for longer and on more varied routes, thus supporting the findings using the map-and-grid system. These households were more likely to let their dogs off lead, had increased numbers of dogs, and were more likely to own Working, Pastoral or some terrier types. This small group of highly connected dogs are also those walked more frequently in a wider area outside of the map. They are thus involved in a much larger network of dogs than that described here, and may act as important disseminators for transmitting diseases through the wider population. This study provides some useful indicators of dog and household types where particular efforts could be directed in preventive disease measures, for example vaccination. However, even if reliable data were available for each community, would owners be able to correctly identify their own dogs as 'highly connected' in order to choose to vaccinate?

When considering green space areas only, the households divided approximately into three groups and the areas into two. This division of the dog population may act to slow transmission of pathogens, and may enable targeted intervention to be applied.

However, there was still considerable interconnectedness, both within and between the household clusters, which may limit the effectiveness of any intervention.

4.4.5 The impact of walk times

The effect of time of walking was investigated, in order to focus on the possibility of direct contact transmission, and separate networks were constructed for those households that responded that they walked at different times of day to those that walked at varied times. Omission of households which reported varying times of dog walking from this analysis would result in underestimation of the connectedness of the networks; conversely, inclusion in each time network incorrectly assumes that these households are present all day and would lead to an overestimation of the contact possible between dogs. The general structure of the networks appeared stable through time, but they did have considerably reduced connectedness and increased number of isolates. However, separating the network into time periods did not fragment the network into non-interconnecting clusters and so direct contact transmission pathways were still present across the general network. In reality, dogs are not walked in one discrete time period or another, and analysing based on this assumption is somewhat artificial.

4.4.6 Conclusion

A high level of *potential* contact has been demonstrated between a population of pet dogs through their use of public space, and this has implications for infectious disease transmission and possible intervention strategies. The community was in a semi-rural area and conclusions may be limited to this area, and it is unknown how much the results can be generalised to other areas. However, more urban areas are likely to have less available green space for dog-walking and this may lead to further concentration of dog walking in these few popular areas. Another limitation of the study is that the contact definition used was necessarily relatively imprecise due to the data collection method, and in reality the actual extent of contact may be reduced due to human and dog behaviours. Further studies, investigating possible contact behaviours and their frequencies are needed to better elucidate the potential for transmission of important pathogens through dog owning communities. However, collection of appropriate data for such studies is difficult and relies on observational data collection (although the presence of observers may alter behaviour). In the longer term, pathogen-specific contact networks should also be explored.

CHAPTER FIVE

RISK FACTORS FOR *CAMPYLOBACTER UPSALIENSIS* CARRIAGE IN A COMMUNITY OF PET DOGS IN THE UK

Faecal collection was carried out by L. Nicolson and laboratory work by C. Porter. All epidemiological analysis was then conducted by C. Westgarth, the author of this thesis.

This Chapter is in preparation for publication:
C. Westgarth, C. J. Porter, L. Nicolson, R. J. Birtles, N.J. Williams, C.A. Hart, G.L. Pinchbeck, R.M. Gaskell, R.M. Christley, and S. Dawson.
Prevalence of *Campylobacter* spp. and risk factors for *C. upsaliensis* carriage in pet dogs from a community in the UK.

ABSTRACT

Campylobacter is the most common bacterial cause of gastrointestinal infectious disease in humans in England and Wales, and pet dogs have been indicated as a risk factor for human infection. Most human cases of disease are associated with *C. jejuni/C.coli*, although other species such as *C. upsaliensis* have been reported. *Campylobacter* spp. carriage rates in healthy pet dogs are unknown.

This study sampled 183 healthy pet dogs in a community in Cheshire and used culture methods to detect any *Campylobacter* spp. and additionally direct PCR to detect *C. upsaliensis*. By any method, forty-eight of 183 dogs were positive for *Campylobacter* spp. making an overall prevalence of (26.2%, 95% CI 20.0-33.2). Thirty-nine of the 183 (21.3%, 95% CI 15.6-28.0) dogs were positive for *Campylobacter* spp. using culture methods. Of these 183 dogs, 37 (20.2%, 95% CI 14.7-26.8) were identified as having *C. upsaliensis*; one (0.5%, 95% CI 0.0-3.0) had *C. jejuni* and one (0.5%, 95% CI 0.0-3.0) had *C. lari.* Forty-three (23.5%, 95% CI 17.6-30.3) of the 183 dogs were positive for *C. upsaliensis* by the direct PCR method. Nine of the forty-three were only positive by direct PCR (not detected by culture). In contrast, three that had previously cultured positive were not detected by the direct PCR method.

Multivariable logistic regression identified risk factors for *C. upsaliensis* carriage (culture or direct PCR) as: living with a positive dog; living in a household with pet fish; being a small dog compared to medium; being under 3 years; being fed commercially-bought dog treats; and being fed human food tit-bits (particularly the act of feeding leftovers in the bowl, although letting the dog feed directly from a plate had a protective effect). These results have implications for prevention of *C. upsaliensis* carriage in pet dogs and the subsequent possible transmission to people.

5.1 INTRODUCTION

5.1.1 Campylobacter in humans

Campylobacter is the most common bacterial cause of gastrointestinal infectious disease in humans in England and Wales (Frost 2001). *Campylobacter jejuni* is the most frequently isolated species followed by *C. coli,* but other species including *C. upsaliensis* may also be isolated from patients with diarrhoea (Lastovica and Le Roux

2001, 2003; Lopez and others 1998). Most cases of campylobacteriosis in humans are non-epidemic, but there appears to be a higher prevalence in children (Gillespie and others 2003). Seasonality due to campylobacter infection has also been observed, with a peak incidence in May and September, which varies between specific subtypes of *C. jejuni* with some having a distinct peak while others are more constant throughout the year (Frost 2001). Although rare, infection with *Campylobacter* spp. has also been associated with neuropathies, such as Miller-Fisher syndrome or Guillain-Barre syndromes (Tam and others 2003).

A number of risk factors for human infection have been identified, which include the consumption of undercooked poultry, raw milk or untreated surface water (Adak and others 1995; Altekruse and others 1999; Altekruse and Tollefson 2003; Frost 2001). In addition, contact with livestock or having a household pet, especially puppies with diarrhoea, are also established risk factors (Adak and others 1995; Brieseman 1990; Gillespie and others 2003; Salfield and Pugh 1987; Tenkate and Stafford 2001). It has been suggested that the prevalence of the disease can be reduced by the thorough control of processing meat products, improving food management and by improved hygiene when handling pets (Altekruse and Tollefson 2003).

5.1.2 Campylobacter in pets

Campylobacter species are frequently found in household pets such as dogs and cats, including healthy puppies and kittens (Hald and Madsen 1997). The most commonly isolated species from dogs are *C. upsaliensis* (Baker and others 1999; Engvall and others 2003; Hald and others 2004; Sandberg and others 2002) and *C. jejuni* (Hald and Madsen 1997; Lopez and others 2002; Torre and Tello 1993; Tsai and others 2007; Workman and others 2005), whereas in cats *C. helveticus* is also found (Rossi and others 2008; Wieland and others 2005; Workman and others 2005). Whether or not *Campylobacter* spp is associated with clinical disease in dogs is not clear. Although the organism has been associated with diarrhoea, especially in younger puppies (Burnens and others 1992; Fleming 1983; Nair and others 1985), more recent epidemiological studies have found no significant difference between campylobacter carriage in dogs with diarrhoea and healthy animals (Baker and others 1999; Lopez and others 2002; Rossi and others 2008; Sandberg and others 2002).

A number of studies on the prevalence of *Campylobacter* spp. in dogs have been carried out, the majority using samples obtained from veterinary practices or kennels (Acke and others 2006; Hald and Madsen 1997; Sandberg and others 2002; Torre and Tello 1993; Tsai and others 2007; Wieland and others 2005). Studies on dogs from private households are less common, although both cross sectional and longitudinal studies have been reported from Sweden and Denmark (Engvall and others 2003; Hald and others 2004), and a census based study from South America (Lopez and others 2002). In general, prevalence appears to be higher in kennelled dogs (Acke and others 2006; Baker and others 1999; Torre and Tello 1993). A previous risk factor study in Switzerland suggested that young cats and dogs had significantly higher odds of carrying *C. upsaliensis/C. helveticus* than older animals (OR 1.8-3.3) (Wieland and others 2005). There was strong evidence that there are differences in the epidemiology of *C. upsaliensis* and *C. jejuni* infection in dogs and they should be treated separately. A similar study in Norway also agreed that young dogs (≤1yr) had increased infection rates, and also suggested carriage was higher in the spring (Sandberg and others 2002).

5.1.3 Aims of this study

The aim of the present study was to determine the prevalence for carriage of *Campylobacter* spp. in healthy pet dogs in a census-based, cross sectional sample of households from a specific community in the UK, and to investigate risk factors for *C. upsaliensis* carriage.

5.2 METHODS

5.2.1 Sample collection and Campylobacter isolation

Two hundred and forty-four fresh dog faecal samples were requested from the owners that had participated in Chapter 3, soon after return of their questionnaire. The excluded dogs (35) had either moved, died or the owners were otherwise non-contactable. Sixty-two percent of dogs were the only dog in the household, 33% one of two dogs, and 5% one of three dogs. All dogs in the household were sampled apart from one dog that had died and one that had been rehomed since initial recruitment, both from two-dog households. Owners were also asked to complete a further short questionnaire for each dog, investigating vomiting, diarrhoea and antibiotic use over the past week, month and year. Samples were collected new plastic bags in the morning and transported to the nearby laboratory for immediate processing, over the period August-November 2005. To maximise the rate of recovery of *Campylobacter* species three different culture methods were used, and an additional direct PCR method using DNA extracted directly from the faecal samples was also used to detect *C. upsaliensis.* All isolation methods are described in more detail in the Appendix to this chapter.

5.2.2 Data analysis

Data was stored in an Access database (Microsoft Corporation, 2003) and analysed using Excel (Microsoft Corporation, 2003), and Minitab (Minitab release 14.2, Minitab Inc, 2005). Univariable analysis using Chi-Squared, Fisher's Exact and Binary Logistic Regression analyses were used to identify possible risk factors for isolation of *Campylobacter upsaliensis* only (by either isolation method). Variables tested included dog demographics, aspects of dog behaviour, human behaviour, household characteristics, diet, vomiting, diarrhoea and antibiotic use. S-plus (MathSoft Inc, 2000) was used to construct Generalised Additive Models (GAM) of continuous variables such as Age and contact network analysis variables (from Chapter 4). Contact network analysis and Quadratic Assignment Procedure (QAP) was performed using Ucinet (Borgatti 2002). The variable betweenness was also calculated for each node of the contact network, and is defined as the number of geodesic paths that pass through a node, weighted inversely by the total number of equivalent paths between the two nodes (Borgatti and Everett 1997).

A multivariable logistic regression model was built using stepwise elimination (backwards and forwards) for variables identified as $P<0.3$ on univariable analysis. Variables remained in the model if they were significant in the model ($P<0.05$) or if removal resulted in substantial change to the effect of other variables (10% or greater). The effect of clustering of dogs within households was assessed in both univariable and multivariable models by use of multilevel modelling (with household and dog as separate levels) in MLwiN (CMM 2006).

5.3 RESULTS

5.3.1 Prevalence of *Campylobacter* spp.

One-hundred and eighty-three samples were returned. By any detection method the overall prevalence of *Campylobacter* spp was 48/183 (26.2%, 95% CI 20.0-33.2). Forty-six of 183 (25.1%, 95% CI 19.0-32.1) were identified as *C. upsaliensis*. Thirty-nine of the 183 (21.3%, 95% CI 15.6-28.0) dogs were positive for *Campylobacter* spp. using culture methods. Of the 183 dogs, 37 (20.2%, 95% CI 14.7-26.8) were identified as having *C. upsaliensis*; one (0.5%, 95% CI 0.0-3.0) had *C. jejuni* and one (0.5%, 95% CI 0.0-3.0) had *C. lari*. Comparison of the three different culture methods showed that the filtration method identified a higher number that were positive (35/39, 89.7%, 95% CI 75.8-97.1), followed by direct plating (23/39, 59%, 95% CI 42.1-74.4) and enrichment (13/39, 33.3%, 95% CI 19.1-50.2). All three methods were needed to maximise recovery, since samples positive by one method were not necessarily positive by another. Forty-three (23.5%, 95% CI 17.6-30.3) of the 183 dogs were positive for *C. upsaliensis* by the direct PCR method (an additional six to those that had cultured). Three samples that had cultured positive for *C. upsaliensis* were not detected through the direct PCR method.

Completed copies of the second questionnaire (vomiting, diarrhoea and antibiotic use) were returned with 122 (67%) of the samples, of which 38 (31%) had *Campylobacter* spp.

5.3.2 Univariable analysis

Univariable analysis was performed for *C. upsaliensis* only (46 positives by either method, culture or direct PCR). Full univariable results are presented in the Appendix for this chapter (Tables 1-8). The variable: lives alone, with other dogs who are negative, or with at least one other dog who is positive, was found to be significantly associated with *C. upsaliensis* status (Table 5.1). A relationship approaching significance was also seen for number of dogs in the household (P=0.07), probably related to the effect of living with another positive dog. Presence of fish as other pets in the household was significantly associated with an animal being *C. upsaliensis* positive and living with any 'other' pets, including livestock, was borderline significant (Table 5.1).

Table 5.1. Univariable analysis of household/dog characteristics and C. upsaliensis status – significant findings (P<0.05) only.
For Tables including non-significant variables please see Appendix to Chapter 5, Tables 1-2

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Lives with a + dog?							**<0.001$**
Alone	85	29	0		1		
Other dogs but no Campylobacter	43	5	-1.08	0.52	0.34	0.12-0.94	
Other dogs at least one Campylobacter positive	7	10	1.43	0.54	4.19	1.46-12.01	
Fish							**0.01**
No	117	31	0		1		
Yes	20	15	1.04	0.40	2.83	1.30-6.16	
Other pets and livestock							**0.05***
No	136	43	0		1		
Yes	1	3	2.25	1.17	9.49	0.96-93.61	
Size							**0.03**
Toy/small	33	20	0		1		
Medium	60	12	-1.10	0.42	0.33	0.14-0.76	
Large/giant	43	14	-0.62	0.42	0.54	0.24-1.22	
Approx age years							**<0.01**
Constant			-0.30	0.35			
Continuous variable			-0.14	0.05	0.87	0.78-0.96	
Approx age years							**<0.001**
Less than 3 yrs	11	13	0		1		
3 yrs or older	123	28	-1.65	0.46	0.19	0.08-0.47	
Source of dog							**0.05**
From person who bred it	73	33	0		1		
Rescue centre	30	9	-0.41	0.43	0.66	0.28-1.55	
Other	32	4	-1.29	0.57	0.28	0.09-0.85	

*= Fisher's Exact P-value instead of Chi-squared.
$= 1 or more cells with expected counts less than 5.

When investigating dog demographic information and acquisition of the dog, the size of the dog was significantly associated with *C. upsaliensis* status, with medium sized dogs and having reduced odds compared to toy/small (Table 5.1). Age was also significant with younger dogs having an increased tendency for being positive (Fig.5.1, Table 5.1). The GAM plot indicated that the relationship between age and the log-odds of being *C. upsaliensis* positive could be modelled as linear (as P=0.18, Fig.5.2). However, the recorded age was often estimated, and commonly measured to the nearest year. For the final model, it was decided to categorise age as under 3 years, or 3 years or older, due to the shape of the GAM plot, with a relatively sharp decrease up to this age (Table 5.1). There was also an indication of differences in campylobacter status for dogs from different sources, with dogs acquired from the person who bred it having higher odds than those from rescue centres and from other sources (Table 5.1).

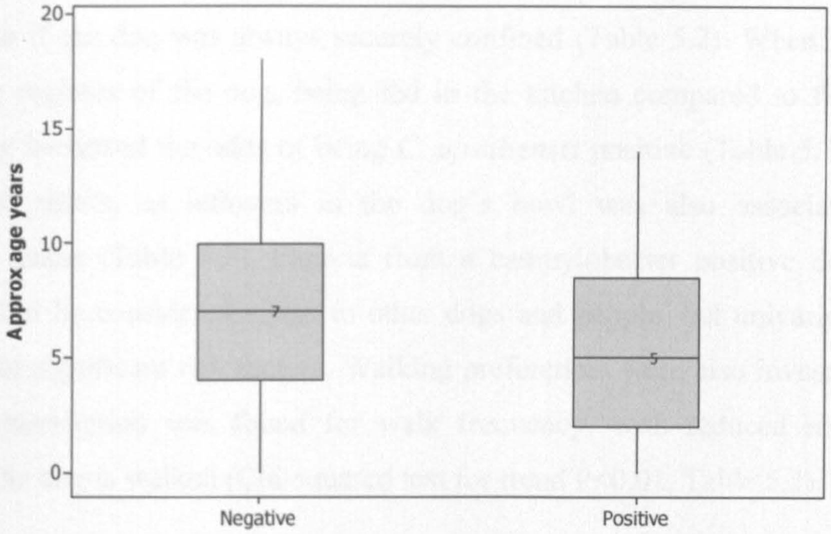


Figure 5.1. Univariable analysis of association of age with *C. upsaliensis* status.

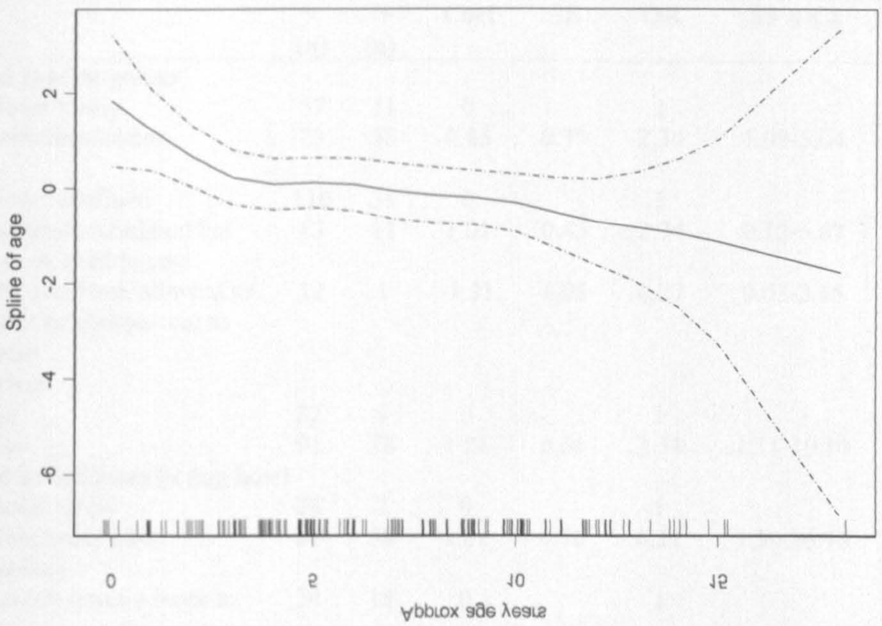


Figure 5.2 GAM plot of age of dog against log-odds of isolation of *C. upsaliensis* (P=0.18).

No significant associations were found between health of the dog or veterinary care or illnesses and *C. upsaliensis* status. No significant association was found between campylobacter status and eating faeces, eating from carcasses, or rolling in carcasses or faeces. Increased frequency of playing rough and tumble games with the dog appeared to be significantly associated with an increased risk of the dog being positive for *C. upsaliensis* (Table 5.2). Investigation of whether the dog was allowed to roam unattended away from the premises suggested increased odds of *C. upsaliensis* carriage if generally confined but had escaped in past, reduced odds if not confined at all, compared to if the dog was always securely confined (Table 5.2). When investigating the feeding regimes of the dog, being fed in the kitchen compared to fed elsewhere significantly increased the odds of being *C. upsaliensis* positive (Table 5.2). Being fed human food titbits, as leftovers in the dog's bowl was also associated with *C. upsaliensis* status (Table 5.2). Excreta from a campylobacter positive dog and their disposal could be considered a risk to other dogs and people, but univariable analysis suggested no significant risk factors. Walking preferences were also investigated and a significant association was found for walk frequency, with reduced risk the more frequently the dog is walked (Chi-squared test for trend P<0.01, Table 5.2).

Table 5.2. Univariable analysis of dog-specific behaviours/management and <u>C. upsaliensis</u> status – significant (P<0.05) findings only.
For tables including non significant findings please see Appendix to Chapter 5, Tables 3-7

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Rough and tumble games							**0.03**
Never/rarely	57	11	0		1		
Sometimes/often	73	33	0.85	0.39	2.34	1.09-5.04	
Roaming							**0.02$**
None, confined	110	34	0		1		
Generally confined but has escaped in past	13	11	1.01	0.45	2.74	0.12-6.67	
Not confined, allowed to roam or chooses not to roam	12	1	-1.31	1.06	0.27	0.03-2.15	
Fed in kitchen							**0.03**
No	32	4	0		1		
Yes	91	38	1.21	0.56	3.34	1.11-10.10	
Tit-bits fed as leftovers in dog bowl							**0.01**
Never/rarely	28	2	0		1		
Sometimes/often	87	38	1.81	0.76	6.11	1.39-26.98	
Walk frequency							**0.01**
Several times a week or less	24	18	0		1		
Once a day	39	12	-0.89	0.45	0.41	0.17-1.00	
Twice a day or other	74	16	-1.24	0.42	0.29	0.13-0.65	
						Chi Square for trend	**<0.01**

$ = 1 or more cells with expected counts less than 5.

During analysis of the contact networks formed between dog owning households and walking areas, variables describing the characteristics of the networks were created (Chapter 4). Two types of walking areas were investigated; one created using a grid system over a map to record any grids entered by the household; and another only considering park/footpath areas termed 'green areas' (n=17) where the dog is more likely to be off lead. These variables were used in univariable analysis to test for associations with *C. upsaliensis* carriage of each dog in the households and significant findings are presented in Table 5.3. Degree describes the number of other nodes in the network that the household links to; in a two mode network this was number of areas visited, in a one-mode network this was the number of other households that could be contacted directly through common walking areas.

GAM plots were constructed for each variable, to confirm that the relationship was not significantly different to linear (see Appendix to this Chapter, Figures 1-6). For the variable of household betweenness (in the two-mode green areas network) the relationship was significantly non-linear and so the data were centralised (betweenness – average), and this and the quadratic form included in the model (Fig 5.3, Table 5.3). An alternative method was to recode betweenness as a maximum of 100, as this was linear, but this variable was not significantly associated. In addition, the variable household degree for the one-mode green areas network was non-linear (Fig.5.4) and subsequently modelled by truncation at maximum 75 instead, or by inclusion of the quadratic form (following centralisation) (see Appendix to this Chapter, Table 8).

Table 5.3. Univariable analysis of contact network variables and *C. upsaliensis* status - significant (P<0.05) findings only.
For non-significant findings, please see Appendix to Chapter 5, Table 8.

Variable per dog	Coef	SE	OR	95% CI	P-value
Household betweenness (n=174)					
for two-mode green areas network	0		1		
Centralised betweenness / 10	0.56	0.18	1.76	1.24-2.50	**<0.01**
Centralised betweenness /10 squared	-0.05	0.02	0.95	0.92-0.99	**0.01**

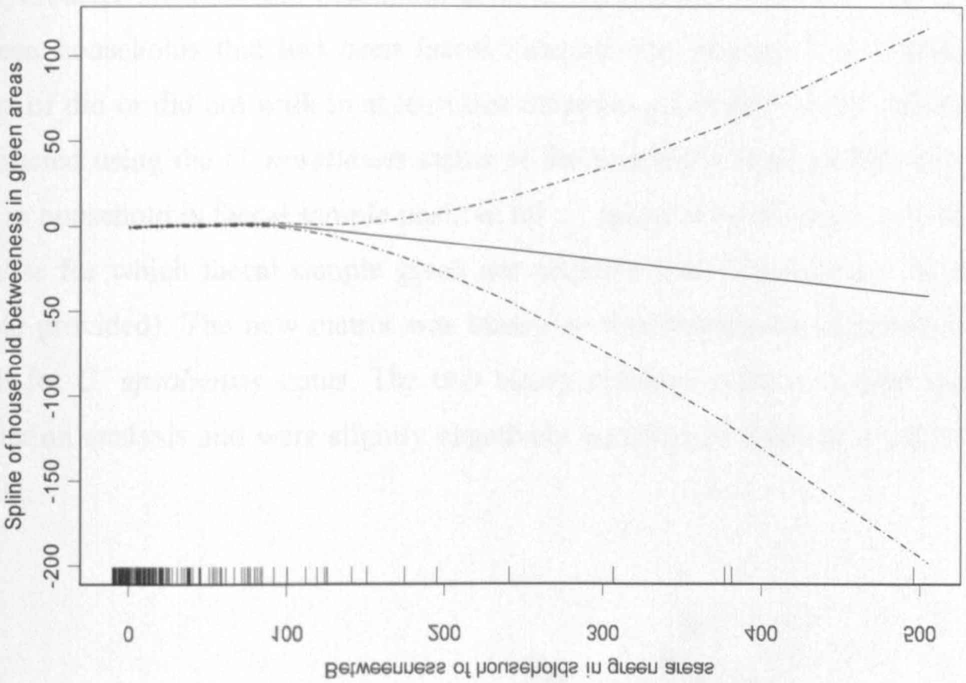


Figure 5.3 GAM plot of household betweenness per dog for two-mode green areas network (P=0.02).

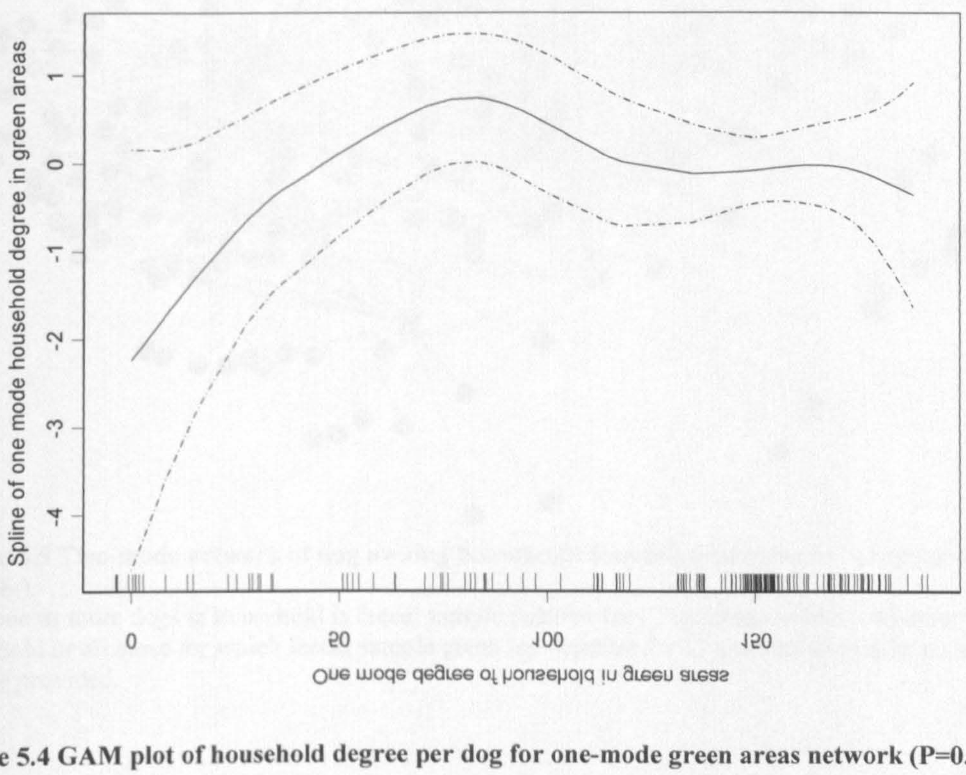


Figure 5.4 GAM plot of household degree per dog for one-mode green areas network (P=0.04).

The two-mode network of green areas and households was visualised and the campylobacter status of the household used as an attribute (Fig.5.5). The association between households that had been faecal sampled was measured in a dichotomised matrix of did or did not walk in at least one common green area. A second matrix was constructed using the *C. upsaliensis* status of the household (categorised: one or more dogs in household is faecal sample positive for *C. upsaliensis*; all dogs in household or all those for which faecal sample given are negative for *C. upsaliensis*; or no faecal sample provided). The new matrix was binary so that households matched or did not match for *C. upsaliensis* status. The two binary matrices were compared using QAP correlation analysis and were slightly negatively correlated (-0.08) at a significance of P=0.02.

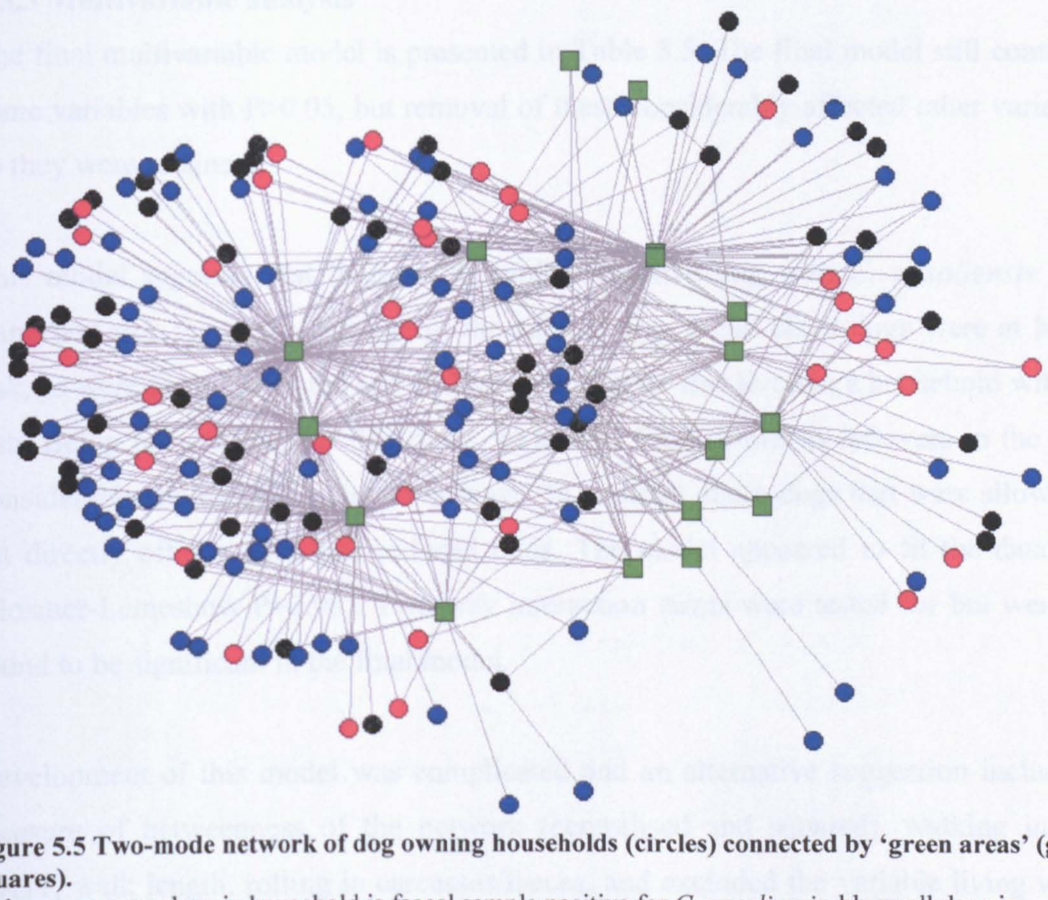


Figure 5.5 Two-mode network of dog owning households (circles) connected by 'green areas' (green squares).
Red=one or more dogs in household is faecal sample positive for *C. upsaliensis*, blue= all dogs in household or all those for which faecal sample given are negative for *C. upsaliensis*, black=no faecal sample provided.

The number of positive and negative households walking in each green area were compared and there was an increased risk of being positive if walked in green area 14, that approached significance (P=0.07, see Appendix to Chapter 5, Table 9). This variable was also analysed at the dog level; use of GA11 was associated with decreased risk and GA14 increased risk (both P=0.02, Table 5.4).

Table 5.4 Univariable analysis of dog *C. upsaliensis* status (n=189) and whether walked in each green area - significant (P<0.05) findings only.
For table including non-significant variables see Appendix to Chapter 5, Table 10

Variable		- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
GA11								0.02
	No	71	33	0		1		
	Yes	58	11	-0.90	0.39	0.41	0.19-0.88	
GA14								0.02
	No	115	33	0		1		
	Yes	14	11	1.01	0.45	2.74	1.14-6.60	

5.3.3 Multivariable analysis

The final multivariable model is presented in Table 5.5. The final model still contained some variables with P>0.05, but removal of these considerably affected other variables, so they were retained.

This model suggests that living with another positive dog with *C. upsaliensis* is an important risk factor for carriage in the subject dog. Small sized dogs were at higher risk, as were those under the age of 3 years and those that lived in a household with pet fish. Being fed commercial dog treats, or human food tit-bits as leftovers in the bowl considerably increased the risk of carriage. In contrast, those dogs that were allowed to eat directly off the plate had reduced odds. The model appeared to fit the data well (Hosmer-Lemeshow P=0.98). Two-way interaction terms were tested for but were not found to be significant in the final model.

Development of this model was complicated and an alternative suggestion included a measure of betweenness of the network (centralised and squared), walking in area GA11, walk length, rolling in carcasses/faeces, and excluded the variable living with a positive dog. However, this alternative model had very wide confidence intervals for the tit-bits variables odds ratios. The final chosen model was also tested as a multi-level hierarchical model allowing for dogs to be contained in households, but there was no differences seen, mainly due to the variable 'lives with a positive dog' accounting for this variation.

Table 5.5 Multivariable model of variables associated with *C. upsaliensis* carriage in dogs (n=125, 58 missing values). Hosmer-Lemeshow P=0.98.

Variable	Coef	SE	OR	95% CI	P-value
Lives with a + dog?					**0.02**
Alone (single dog)	0		1		
Other dogs but no positive	-1.31	0.83	0.27	0.05-1.39	
Other dogs at least one positive	1.69	0.86	5.43	1.00-29.41	
Fish					**0.05**
No	0		1		
Yes	1.36	0.68	3.91	1.03-14.81	
Size					**0.01**
Toy/small	0		1		
Medium	-2.59	0.85	0.08	0.0-0.39	
Large/giant	-0.23	0.63	0.80	0.23-2.76	
Approx age years					**<0.01**
Less than 3 yrs	0		1		
3 yrs or older	-2.55	0.88	0.08	0.01-0.44	
Tit-bits fed as leftovers in dog bowl					**0.01**
Never/rarely	0		1		
Sometimes/often	2.52	0.98	12.44	1.84-84.25	
Tit-bits fed from plate					**0.05**
Never/rarely	0		1		
Sometimes/often	-1.49	0.76	0.23	0.05-1.01	
Fed commercial dog treats					**0.08**
Never/rarely	0		1		
Sometimes/often	1.48	0.84	4.41	0.85-22.98	

5.3.4 Comparing culture positives with PCR positives only

The 37 samples which were culture positive and direct PCR positive for *C. upsaliensis* were compared with the nine that were direct PCR positive but did not culture. This was performed for a number of demographic variables and a selection of other variables that seemed to be considerably affected after addition of the direct PCR results to the data (Table 5.6). Presence of a 6-19 year old was significantly associated with an increased odds of being PCR positive but not culture (P=0.03). Being fed human food tit-bits was significantly associated with a much decreased likelihood of being positive by PCR but not cultured (P=0.02).

Table 5.6. Comparison of culture positives with PCR only positives - significant (P<0.05) findings only.
For table including non-significant variables, see Appendix to Chapter 5, Table 11.

Variable	Cult (n)	PCR only (n)	Coef	SE	OR	95% CI	P-value
Presence of 6-19yr old							**0.03***
No	24	2	0		1		
Yes	13	7	1.87	0.87	6.46	1.17-35.74	
Fed human food tit-bits							**0.02***
No	1	3	0		1		
Yes	36	6	-2.89	1.24	0.06	0.00-0.63	

*= Fisher's Exact P-value instead of Chi-squared.

5.4 DISCUSSION

5.4.1 Prevalence

In this study, the prevalence of *Campylobacter* spp. in healthy dogs from a community in a small semi-urban town in the UK was 26.2%. This is comparable to other cross sectional studies which showed prevalences of 23 and 29% of *Campylobacter* spp. in healthy dogs or puppies attending veterinary practices in Sweden (Sandberg and others 2002) or Denmark (Hald and Madsen 1997). Other studies have reported higher levels of campylobacter isolation from dogs. A Swiss veterinary practice study found a 41.2% prevalence in healthy pet dogs (Wieland and others 2005), and an earlier UK study found 33.9% in 56 pet dogs from various sources (Moreno and others 1993). In a recent study of Irish shelter dogs a high rate of *Campylobacter* carriage (87.5%) was reported from healthy dogs (Acke and others 2006). The differences between studies, and in particular the higher prevalences found in some studies, may have been due to the different sample populations; ie kennelled dogs or vet-visiting dogs, compared to owned pet dogs in the community.

5.4.2 *Campylobacter* species

The predominant species found in dogs in this study was *C. upsaliensis*. Other reports have also found *C. upsaliensis* to be the predominant species isolated from dogs accounting for 64 to 82% of the strains isolated (Engvall and others 2003; Hald and others 2004; Sandberg and others 2002). In contrast other workers have found a predominance of *C. jejuni* from canine samples (Baker and others 1999; Fernandez and Martin 1991; Hald and Madsen 1997; Lopez and others 2002; Torre and Tello 1993; Tsai and others 2007; Workman and others 2005). Most of these studies show a significantly higher prevalence in stray dogs than in household dogs, which may suggest that stray dogs have more exposure to environmental sources of campylobacter than do household pets. Both the sample populations and the isolation/detection methods in different studies used may have an impact on the *Campylobacter* spp. isolated (Engberg 2006; Lastovica and Le Roux 2003).

5.4.3 Living with another *C. upsaliensis* positive dog

A number of variables appeared to be associated with carriage of *C. upsaliensis* in this community of dogs. On multivariable analysis, the most important variables were: living with a dog with campylobacter; living in a household with pet fish; size of dog; age of dog; being fed human food tit-bits in the bowl or off a plate; and being fed commercial dog treats. Living with another dog that did not carry *C. upsaliensis* was suggested to be protective, whereas living with a dog that was positive significantly increased the likelihood of carriage, compared to living as a single dog. This suggests that dogs in households together may infect each other, however some of this association may also be due to living in a common environment and being managed in a similar manner by the owner. However, for a dog that lived alone there was a higher risk than if in a multiple dog household where no other dog was positive. If a reduced risk was due to lack of exposure, it would be expected that single dogs would be as similarly unexposed as two non-carrier dogs that lived in the same household, therefore it is more reasonable to suggest that some dogs are passing the infection to other dogs in the household. This finding has not been observed before, however the authors know of no studies of a similar design where all dogs in a household were sampled.

5.4.4 Living with fish

The significant association with pet fish is an unusual finding and has not been observed before. We believe it is unlikely that the association is due to direct contact with the fish or the fish's water, as many of the fish were in tanks rather than ponds (personal note when conducting the Dogs in the Community Survey); this variable may be a 'proxy measure' for another important variable not considered in our study. However, possible associations with water have been noted previously (Wieland and others 2005) by the variables living close to a lake and drinking out of puddles/swimming, although these factors were not considered important after multivariable analyses. In future studies it would be interesting to consider whether the pet fish were in a pond or a tank, to quantify the amount of contact the dogs have with the water and the fish food, and to even take samples of the water and food in order to test for presence of *Campylobacter* spp.

5.4.5 Size of dog

A finding not reported previously is that toy/small dogs were at increased risk compared to medium dogs, who were the lowest risk group. It is plausible that small dogs were more likely to live in multi-dog households than larger dogs or that they were more likely to be fed tit-bits in their bowl, but there was no evidence for an association between these variables (P=0.27 for both, data not shown), and all these variables remained in the final multivariable model. Similarly, the smaller dogs were not walked less often either (P=0.45, data not shown). An alternative explanation is that certain small breeds of dogs are for some reason more likely to be colonised by the pathogen, due to gut morphology, or behaviour/management by owners. It has been previously reported that different sized dogs behave differently in the home (Chapter 3). Hence, the increased risk for smaller breeds may be due to behavioural differences, which may increase exposure.

5.4.6 Age of dog

Younger dogs were at increased risk, as has been shown previously in other studies (Sandberg and others 2002; Wieland and others 2005) and may be due to an 'immunization' affect with age, or levels dropping below culture detection, although in our study the use of a direct PCR method may have increased the sensitivity of detection. It may be sensible to consider the age of the dog when selecting pets for homes containing people at high risk of infection.

5.4.7 Diet

Feeding the dog some types of human food tit-bits or commercial dog treats appeared to be associated with an increased risk of *C. upsaliensis* carriage. In particular, feeding the dog leftover human food in its bowl greatly increased the risk, possibly because this may be spoiled food deemed unsuitable for human consumption. Leftovers may collect in the dog bowl throughout the day, become contaminated with Campylobacter *spp.*, and remain there until the dog is fed. However, raw foods, especially meats, are more generally indicated as a source of *Campylobacter* spp. rather than cooked foods (Anon, 2000), and few dogs in this study were reported to be fed raw meat (Chapter 3).

In contrast, food fed directly from a human plate led to a reduced likelihood of *C. upsaliensis* carriage in dogs. The reasons for this are unknown, but could relate to either reduced exposure (because the food is more likely to be suitable human consumption), or it may relate to some form of resistance/immunity. It is also possible that the data reported on feeding of tit-bits is unreliable and biased due to the sensitive nature of the subject and opinions on the practice of feeding tit-bits to dogs. More studies are needed to investigate this as a possible risk factor, for example experimental studies of whether pathogens can be isolated from human food fed to dogs or from the dog bowl, and the time periods required for contamination to occur in left-over food.

It is not known if the increased risk of *C. upsaliensis* carriage found in dogs fed commercially bought treats is a proxy measure for some other unstudied variable, or whether it relates to contamination of the treats. Chews such as pigs' ears may be more likely to be a source of campylobacter than processed treats such as biscuits. This could be investigated by more detailed questions on the types of treats given, or sampling the foods directly and testing for presence of *Campylobacter* spp. Again the food may become contaminated during preparation, or afterwards e.g. a bag of treats open for an extended period.

5.4.8 Alternative model

Construction of a final explanatory model was not simple, and an alternative model included a measure of betweenness for each household, walking in area GA11 and walk length. This model also contained rolling in carcasses/faeces and excluded the variable living with a positive dog. However, this alternative model produced very wide confidence intervals (in particular for the tit-bits variables) and the relationship of betweenness with *C. upsaliensis* status was not straightforward to explain. Therefore it was decided that the principal model presented here was more suitable for the data, and living with a positive dog was thought to be a sufficiently biologically important variable to warrant inclusion in this model. Variables that were significant on initial analysis but then did not prove important after multivariable analysis (e.g. games, walk frequency), were probably due to confounding effects with age and size of dog, as these have been shown to be associated with a number of behaviours and management aspects previously (Chapter 3).

5.4.9 Culture versus PCR

When comparing the small number of samples that were both culture and direct PCR positive, with those that were PCR positive, but were not culture positive, no significant differences were found for basic dog demographic information and vomiting, diarrhoea and antibiotic use. However, positive samples that did not culture were six times more likely to have come from a dog in a household where a 6-19yr old person was present. In contrast, samples that cultured were more likely to be from dogs fed human food tit-bits than those that were only positive by direct PCR. Therefore it is plausible that these dogs may be being infected with a viable *C. upsaliensis* (that will culture) via leftover food. Because of these differences, it is possible that the *C. upsaliensis* detected via culture, and detected via direct PCR, may be of different subtypes, or maybe a viable and non-viable (non-culturable) form. In particular, the organisms isolated from dogs in households with 6-19yr olds people may be associated with that human age group for some reason. Alternatively, these results may of course be due to a Type I Error and it is important to remember that there was only a small amount of data to use in this part of the analysis.

5.4.10 Conclusion

Overall, many dogs in this community appear to be shedding *Campylobacter spp.*, which may be of significance to public health. Many of the canine infections involve *C. upsaliensis* which is reported as a cause of human campylobacteriosis, although less frequently than *C. jejuni.* These dogs were apparently healthy and no association was found with vomiting or diarrhoea, and so the ability of the pathogen to cause clinical disease is probably low. Factors associated with *C. upsaliensis* infection in dogs were identified, such as feeding human food leftovers in the bowl. Intervention to prevent such activities may be useful in reducing the likelihood of campylobacter shedding from pet dogs especially where members of the household may be at particular risk from infection and disease.

APPENDIX TO CHAPTER FIVE

Culture methods

Faecal homogenates were prepared in 1 in 10 dilution of 0.85% sodium chloride solution. The three culture methods for *Campylobacter* species used were (i) direct plating on to Campylobacter selective agar (Lab M, Bury, Lancashire UK) with the addition of a selective supplement cefoperazone and amphotericin (CA) (Lab M, Bury, Lancashire UK). (ii) Campylobacter enrichment broth (Lab M) with vancomycin (Sigma-Aldrich, Poole, UK) (8mg/l) and 10% lysed horse blood (Southern Group Labs Ltd., Corby, UK) incubated for 24 hours then inoculated onto Campylobacter selective agar as in (i); and (iii) filtration onto a 0.7 μm nitrocellulose membrane onto Campylobacter selective agar as in (i) with the addition of cefoperazone, amphotericin and teicoplanin (CAT) (Oxoid) supplement. The broths were incubated for 24 hours and plates for 96 hours at 37°C under microaerophilic conditions in a variable atmosphere incubator (Don Whitely Scientific Ltd, Shipley, UK). Any suspect colonies were subcultured onto Columbia blood agar plates, containing 5% defibrinated horse blood (Southern Group Labs) and incubated for a further 48 hours. Up to five suspect colonies from each plate were selected for further culture and processed for DNA extraction for characterisation. In brief, using a sterile loop a small number of colonies were collected and suspended in 100μl of phosphate buffered saline (PBS) and heated at 100°C for 10 minutes to provide cell lysates for use in future PCR reactions. The remaining growth on these plates was added to Protec microbank vials (Pro-Lab Diagnostics Ltd, Neston UK) and stored at -80°C.

Direct DNA extraction from faecal samples

Faecal suspensions of 5% (wt/vol) in PBS were prepared and clarified by centrifugation for 20mins at 4000 x g. Bacterial DNA was extracted from 140μl of the stool suspensions using a QIAamp RNA kit (QIAGEN Ltd), which extracts both RNA and DNA according to the manufacturer's instructions. The RNA extraction kit was used as the RNA was required for other studies. Total RNA /DNA was eluted in 60μl buffer and stored at -20°C for use in subsequent PCR experiments. Two negative water controls were included for every 20 faecal samples processed.

Species identification

A series of PCR assays targeting selected genes were performed for Campylobacter species-specific identification. Two additional negative PCR controls were included for every 20 samples processed.Regions of the 16S rDNA gene (Linton and others 1996) and *gly A* (Wang and others 2002) were used for *C. upsaliensis* identification and *hip O* (Linton and others 1997) for *C. jejuni*. PCR of the partial *groEL* gene, followed by sequencing, was used to identify and further confirm *C. jejuni* and *C. lari* (Karenlampi and others 2004). Where the DNA was extracted directly from faecal samples, two PCR assays, using regions of the 16S rDNA and *gly A* gene as above, were performed to confirm the identity of each *C. upsaliensis* isolate.

Table 1. Univariable analysis of household characteristics and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Number of dogs							0.07$
Single dog	85	29	0		1		
Two dogs	48	12	-0.31	0.39	0.73	0.34-1.57	
Three dogs	4	5	1.30	0.70	3.66	0.92-14.57	
Lives with a + dog?							**0.01***
No	127	35	0		1		
Yes	8	9	1.41	0.52	4.08	1.47-11.36	
Lives with a + dog?							**<0.001$**
Alone	85	29	0		1		
Other dogs but no Campylobacter	43	5	-1.08	0.52	0.34	0.12-0.94	
Other dogs at least one Campylobacter positive	7	10	1.43	0.54	4.19	1.46-12.01	
Another pet (excluding dogs or cats) in household							0.10
No	101	28	0		1		
Yes	36	18	0.59	0.36	1.80	0.89-3.65	
Cat							0.81
No	111	38	0		1		
Yes	26	8	-0.11	0.45	0.90	0.38-2.15	
Birds							1.0*
No	130	44	0		1		
Yes	7	2	-0.17	0.82	0.84	0.17-4.22	
Fish							**0.01**
No	117	31	0		1		
Yes	20	15	1.04	0.40	2.83	1.30-6.16	
Horse							1.0*
No	130	44	0		1		
Yes	7	2	-0.17	0.82	0.84	0.17-4.22	
Reptiles and amphibians							0.10*
No	135	43	0		1		
Yes	2	3	1.55	0.93	4.71	0.76-29.12	
Small mammals							0.21*
No	128	40	0		1		
Yes	9	6	0.76	0.56	2.13	0.72-6.36	
Other pets and livestock							**0.05***
No	136	43	0		1		
Yes	1	3	2.25	1.17	9.49	0.96-93.61	
Presence of 5yrs old or under							0.23*
No	132	42	0		1		
Yes	5	4	0.92	0.69	2.51	0.65-9.80	
Presence of 6-19yr old							0.11
No	95	26	0		1		
Yes	42	20	0.55	0.35	1.74	0.88-3.46	

*= Fisher's Exact P-value instead of Chi-squared.
$= 1 or more cells with expected counts less than 5.

Table 2. Univariable analysis of dog demographic information and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Kennel club breed type							0.48$
Cross	37	11	0		1		
Gundog/hound	36	9	-0.17	0.51	0.84	0.31-2.27	
Pastoral	21	8	0.25	0.54	1.28	0.45-3.69	
Terrier	14	3	-0.33	0.72	0.72	0.17-2.97	
Toy/utility	11	6	0.61	0.61	1.83	0.55-6.10	
Unrecognised	9	7	0.96	0.61	2.62	0.79-8.65	
Working	9	2	-0.29	0.85	0.75	0.14-3.98	
Size							**0.03**
Toy/small	33	20	0		1		
Medium	60	12	-1.10	0.42	0.33	0.14-0.76	
Large/giant	43	14	-0.62	0.42	0.54	0.24-1.22	
Approx age years							**<0.01**
Constant			-0.30	0.35			
Continuous variable			-0.14	0.05	0.87	0.78-0.96	
Approx age years							**<0.001**
Less than 3 yrs	11	13	0		1		
3 yrs or older	123	28	-1.65	0.46	0.19	0.08-0.47	
Gender							0.58
Male	69	21	0		1		
Female	68	25	0.19	0.34	1.21	0.62-2.36	
Neutered							0.33
No	39	9	0		1		
Yes	98	34	0.41	0.42	1.50	0.66-3.42	
Owned from a puppy							0.90
No	46	15	0		1		
Yes	91	31	0.04	0.36	1.04	0.51-2.13	
Where got dog							**0.05**
From person who bred it	73	33	0		1		
Rescue centre	30	9	-0.41	0.43	0.66	0.28-1.55	
Other	32	4	-1.29	0.57	0.28	0.09-0.85	

*= Fisher's Exact P-value instead of Chi-squared.
$= 1 or more cells with expected counts less than 5.

Table 3. Univariable analysis of general health, vomiting, diarrhoea and antibiotic use and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Vomiting in past year							0.11
None	45	25	0		1		
Sporadic recent or in past	35	9	-0.77	0.45	0.46	0.19-1.12	
Common (6 or more)	4	4	0.59	0.75	1.80	0.41-7.83	
Diarrhoea in past year							0.93
None	46	23	0		1		
Sporadic recent or in past	26	11	-0.17	0.44	0.85	0.36-2.01	
Common (6 or more)	12	4	-0.14	0.63	0.67	0.19-2.30	
Antibiotic use in past year							0.27
No	51	27	0		1		
Yes	33	11	-0.46	0.42	0.63	0.28-1.44	
Been to vet in past year							0.85
No	22	7	0		1		
Yes	112	39	0.09	0.47	1.09	0.43-2.76	
Visited vet for vomiting or diarrhoea in past year							1*
No	126	44	0		1		
Yes	8	2	-0.33	0.81	0.72	0.15-3.50	
Flea treatment in past 3 months							0.49
No	66	20	0		1		
Yes	65	25	0.24	0.35	1.27	0.64-2.51	
Worm treatment in past 3 months							0.34
No	62	18	0		1		
Yes	69	28	0.33	0.35	1.40	0.71-2.77	

*= Fisher's Exact P-value instead of Chi-squared.
$= 1 or more cells with expected counts less than 5.

Table 4. Univariable analysis of dog-specific behaviours/management and *C. upsaliensis* status.

Variable	-	+	Coef	SE	OR	95% CI	P-value
Sleep in kitchen							0.13
Never	44	8	0		1		
Rarely/sometimes	14	7	1.01	0.60	2.75	0.85-8.94	
Often/always	56	23	0.81	0.46	2.26	0.92-5.53	
Sleep on bedroom floor							0.52
Never	50	20	0		1		
Rarely/sometimes	23	6	-0.43	0.53	0.65	0.23-1.84	
Often/always	32	8	-0.47	0.48	0.63	0.25-1.59	
Sleep in bedroom on bed							0.72
Never	59	21	0		1		
Rarely/sometimes	24	6	-0.35	0.52	0.70	0.25-1.96	
Often/always	23	6	-0.31	0.52	0.73	0.26-2.05	
Lie on furniture							0.57
Never/rarely	63	23	0		1		
Sometimes/often	67	20	-0.20	0.35	0.82	0.41-1.63	
Lie on laps							0.83
Never/rarely	74	24	0		1		
Sometimes/often	60	18	-0.08	0.36	0.93	0.46-1.86	
Licks face of visitors							0.33
Never/rarely	92	29	0		1		
Sometimes/often	28	13	0.39	0.40	1.47	0.68-3.21	
Licks hands of visitors							0.35
Never/rarely	71	20	0		1		
Sometimes/often	56	22	0.33	0.36	1.39	0.69-2.81	
Licks face of household members							0.20
Never	47	13	0		1		
Rarely	18	12	0.88	0.49	2.41	0.93-6.26	
Sometimes	37	9	-0.13	0.49	0.88	0.34-2.28	
Often	26	9	0.22	0.50	1.25	0.47-3.32	
Licks hands of household members							0.21
Never/rarely	53	13	0		1		
Sometimes/often	79	31	0.47	0.38	1.60	0.77-3.34	
Fetch games							0.52
Never/rarely	25	6	0		1		
Sometimes/often	109	36	0.32	0.49	1.38	0.52-3.62	
Tug of war games							0.74
Never/rarely	40	12	0		1		
Sometimes/often	91	31	0.13	0.39	1.14	0.53-2.44	
Rough and tumble games							**0.03**
Never/rarely	57	11	0		1		
Sometimes/often	73	33	0.85	0.39	2.34	1.09-5.04	
Roaming							**0.02[$]**
None, confined	110	34	0		1		
Generally confined but has escaped in past	13	11	1.01	0.45	2.74	0.12-6.67	
Not confined, allowed to roam or chooses not to roam	12	1	-1.31	1.06	0.27	0.03-2.15	
Playful with other dogs							0.78
Never/rarely	45	14	0		1		
Sometimes/often	81	28	0.11	0.38	1.11	0.53-2.32	
Sniffs other dogs							0.38
Never/rarely	15	7	0		1		
Sometimes/often	116	35	-0.44	0.50	0.65	0.24-1.71	
Rolls in faeces/carcasses							0.09
Never/rarely	102	29	0		1		
Sometimes/often	32	17	0.63	0.37	1.87	0.91-3.83	

Table 5. Univariable analysis of dog diet and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Diet tinned meat							0.46
No	73	22	0		1		
Yes	62	24	0.25	0.34	1.28	0.66-2.51	
Diet cooked meat							0.60
No	113	40	0		1		
Yes	22	6	-0.26	0.50	0.77	0.29-2.04	
Diet dry complete							0.72
No	45	14	0		1		
Yes	90	32	0.13	0.37	1.14	0.55-2.35	
Diet biscuit mixer							0.46
No	95	35	0		1		
Yes	40	11	-0.29	0.39	0.75	0.33-1.61	
Diet raw veg							1.00*
No	121	41	0		1		
Yes	14	5	0.05	0.55	1.05	0.36-3.11	
Fed in kitchen							**0.03**
No	32	4	0		1		
Yes	91	38	1.21	0.56	3.34	1.11-10.10	
Fed commercial dog treats							0.17
Never/rarely	24	4	0		1		
Sometimes/often	108	39	0.77	0.57	2.17	0.71-6.64	
Fed human food tit-bits							0.78*
No	15	4	0		1		
Yes	119	42	0.28	0.59	1.32	0.42-4.21	
Tit-bits fed from hand							0.52
Never/rarely	29	12	0		1		
Sometimes/often	85	27	-0.26	0.40	0.77	0.34-1.71	
Tit-bits fed as leftovers in dog bowl							**0.01**
Never/rarely	28	2	0		1		
Sometimes/often	87	38	1.81	0.76	6.11	1.39-26.98	
Tit-bits fed from plate							0.26
Never/rarely	83	32	0		1		
Sometimes/often	20	4	-0.65	0.59	0.52	0.16-1.64	
Tit-bits fed from floor							0.93
Never/rarely	64	21	0		1		
Sometimes/often	50	17	0.04	0.38	1.04	0.49-2.17	
Fed raw meat							0.50
Never	110	23	0		1		
Rarely/sometimes	36	10	0.28	0.42	1.33	0.58-3.05	
Eat raw carcasses (e.g. dead bird)							0.72*
Never/rarely	128	43	0		1		
Sometimes/often	7	3	0.24	0.71	1.28	0.32-5.15	
Eat dog faeces							0.74*
Never/rarely	126	42	0		1		
Sometimes/often	9	4	0.29	0.63	1.33	0.39-4.55	

*= Fisher's Exact P-value instead of Chi-squared.

$^{\$}$= 1 or more cells with expected counts less than 5.

Table 6. Univariable analysis of excretion, disposal methods and hygiene and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Dog passes faeces in house							0.15
Never	95	27	0		1		
Rarely/sometimes/often	21	11	0.61	0.43	1.84	0.79-4.29	
Removal of faeces from garden							0.51
Once a week or less	16	4	0		1		
More than once a week	109	40	0.38	0.59	1.47	0.46-4.65	
Use of shovel for garden faeces							0.15
No	68	30	0		1		
Yes	57	15	-0.52	0.36	0.60	0.29-1.22	
Use of a poopscoop for garden faeces							0.38
No	107	36	0		1		
Yes	18	9	0.40	0.45	1.49	0.61-3.60	
Use of plastic bags for garden faeces							0.57
No	36	15	0		1		
Yes	89	30	-0.21	0.37	0.81	0.39-1.68	
No removal of garden faeces							
No	123	45					
Yes - none	2	0					
Dog passes faeces on a walk							1.0*
No	11	3	0		1		
Yes	126	42	0.20	0.68	1.22	0.33-4.59	
Use of a poopscoop for walk faeces							0.19*
No	119	41	0		1		
Yes	12	1	-1.42	1.06	0.24	0.03-1.92	
Use of plastic bags for walk faeces							1.0*
No	10	3	0		1		
Yes	121	39	0.07	0.68	1.07	0.28-4.10	
No removal of walk faeces							0.63*
No	127	40	0		1		
Yes - none	4	2	0.46	0.88	1.59	0.28-8.99	
Use of poo bins in local area							0.94
Never/rarely	25	8	0		1		
Sometimes/often	112	37	0.03	0.45	1.03	0.43-2.49	
Pick up after dog on public path							0.30*
Never/rarely/sometimes	11	1	0		1		
Usually/always	121	40	1.29	1.06	3.64	0.46-29.05	
Pick up after dog in countryside							0.85
Never/rarely/sometimes	43	14	0		1		
Usually/always	89	27	-0.07	0.39	0.93	0.44-1.96	
Pick up after dog in a park							0.53*
Never/rarely/sometimes	13	2	0		1		
Usually/always	119	39	-0.76	0.78	2.13	0.46-9.86	
Pick up after dog in the street							0.25*
Never/rarely/sometimes	16	2	0		1		
Usually/always	116	39	0.99	0.77	2.69	0.59-12.23	
Wash hands before eating							0.66
Never/rarely/sometimes	20	6	0		1		
Usually	47	13	-0.08	0.56	0.92	0.31-2.77	
Always	70	27	0.25	0.52	1.29	0.47-3.55	
Wash hands after touching dog							
Never/rarely/sometimes	63	22	0		1		
Usually	33	13	0.12	0.41	1.13	0.50-2.52	0.77
Always	40	11	-0.24	0.42	0.79	0.35-1.80	

Table 6 (continued). Univariable analysis of excretion, disposal methods and hygiene and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Wash hands after picking up faeces							0.12*
Never/rarely/sometimes/ usually	13	1	0		1		
Always	120	45	1.58	1.05	4.87	0.62-38.35	

*= Fisher's Exact P-value instead of Chi-squared.

Table 7. Univariable analysis of walk preferences and *C. upsaliensis* status.

Variable	- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
Walk in streets							0.48
No	67	19	0		1		
Yes	69	25	0.25	0.35	1.28	0.64-2.53	
Walk in parks							0.07
No	89	22	0		1		
Yes	47	22	0.64	0.35	1.89	0.95-3.77	
Walk on beach/marsh							0.56
No	40	15	0		1		
Yes	96	29	-0.22	0.37	0.81	0.39-1.66	
Walk in countryside							0.65
No	29	8	0		1		
Yes	107	36	0.20	0.44	1.22	0.51-2.91	
Walk in farmland							0.28
No	120	36	0		1		
Yes	16	8	0.51	0.47	1.67	0.66-4.21	
Walk frequency							**0.01**
Several times a week or less	24	18	0		1		
Once a day	39	12	-0.89	0.45	0.41	0.17-1.00	
Twice a day or other	74	16	-1.24	0.42	0.29	0.13-0.65	
						Chi Square for trend	**<0.01**
Walk length							0.09
30mins or less	56	14	0		1		
30mins – 1 hour	63	16	0.02	0.41	1.02	0.46-2.27	
Over 1 hour	15	10	0.98	0.51	2.67	0.99-7.19	
Walk regularly in a group with friends							0.65
Never	50	13	0		1		
Rarely	28	8	0.09	0.51	1.10	0.41-2.97	
Sometimes	41	16	0.41	0.43	1.50	0.65-3.48	
Often/everyday	17	8	0.59	0.53	1.81	0.64-5.11	
						Chi Square for trend	0.20
Notice seeing same dogs on walks							0.12
Never/rarely/sometimes	41	19	0		1		
Often/everyday	94	25	-0.56	0.38	0.57	0.28-1.16	
Walks grouped							0.07
Few walks, do not walk in a group , do not see same dogs.	27	13	0		1		
Walk everyday, not in a group, do see same dogs, short walks.	51	8	-1.12	0.51	0.33	0.12-0.88	
Walk everyday, sometimes in a group, do see same dogs, longer walks.	55	19	-0.33	0.43	0.72	0.31-1.67	

*= Fisher's Exact P-value instead of Chi-squared.

Table 8. Univariable analysis of contact network variables and *C. upsaliensis* status.

Variable per dog	Coef	SE	OR	95% CI	P-value
Household degree (n=174) for two-mode grid areas network	0		1		
Continuous variable	<-0.01	0.01	1.00	0.99-1.01	0.79
Household degree (n=174) for two-mode green areas network	0		1		
Continuous variable	0.02	0.08	1.02	0.87-1.19	0.81
Household degree (n=174) max 6 for two-mode green areas network	0		1		
Continuous variable	0.13	0.11	1.14	0.92-1.42	0.22
Household betweenness (n=174) for two-mode green areas network	0		1		
Centralised betweenness / 10	0.56	0.18	1.76	1.24-2.50	**<0.01**
Centralised betweenness /10 squared	-0.05	0.02	0.95	0.92-0.99	**0.01**
Household betweenness (n=174) max 100 for two-mode green areas network	0		1		
Continuous variable	0.002	0.005	1.00	0.99-1.01	0.63
Household degree (n=174) for one-mode green areas network	0		1		
Centralised degree / 10	-0.06	0.05	0.94	0.84-1.05	0.26
Centralised degree / 10 squared	-0.02	0.01	0.98	0.97-1.00	0.05
Household degree (n=174) max 75 for one-mode green areas network	0				
Continuous variable	0.02	0.01	1.02	1.00-1.05	0.09

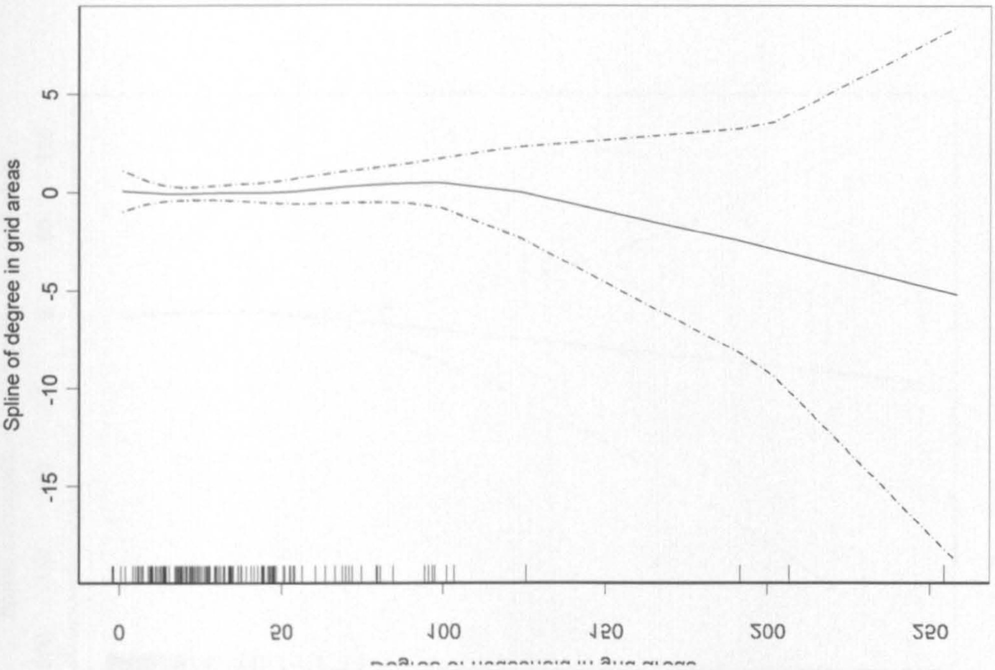


Figure 1. GAM plot of household degree per dog for two-mode grid areas network (P=0.45).

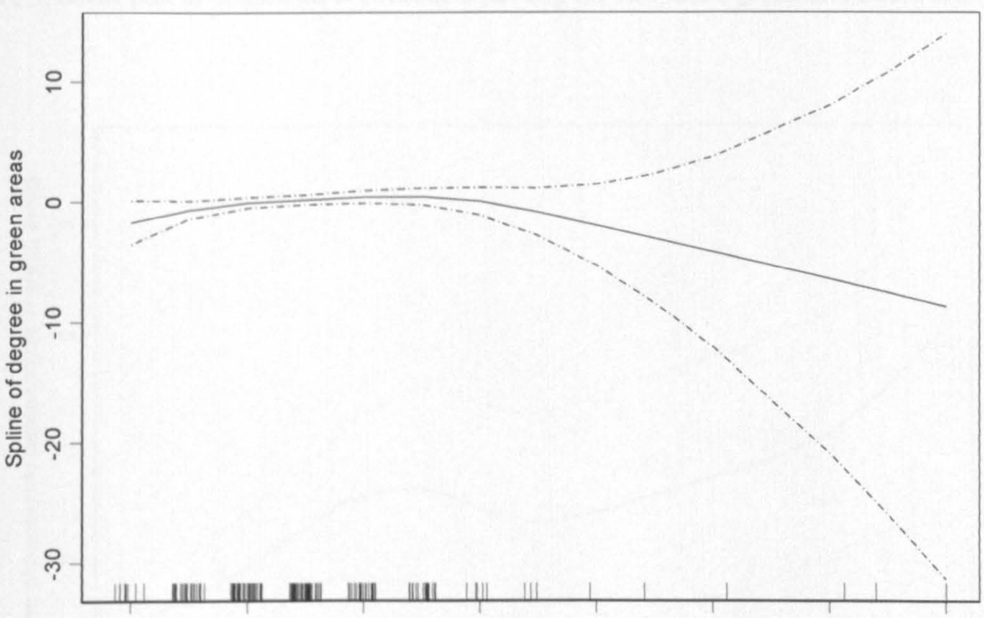


Figure 2. GAM plot of household degree per dog for two-mode green areas network (P=0.11).

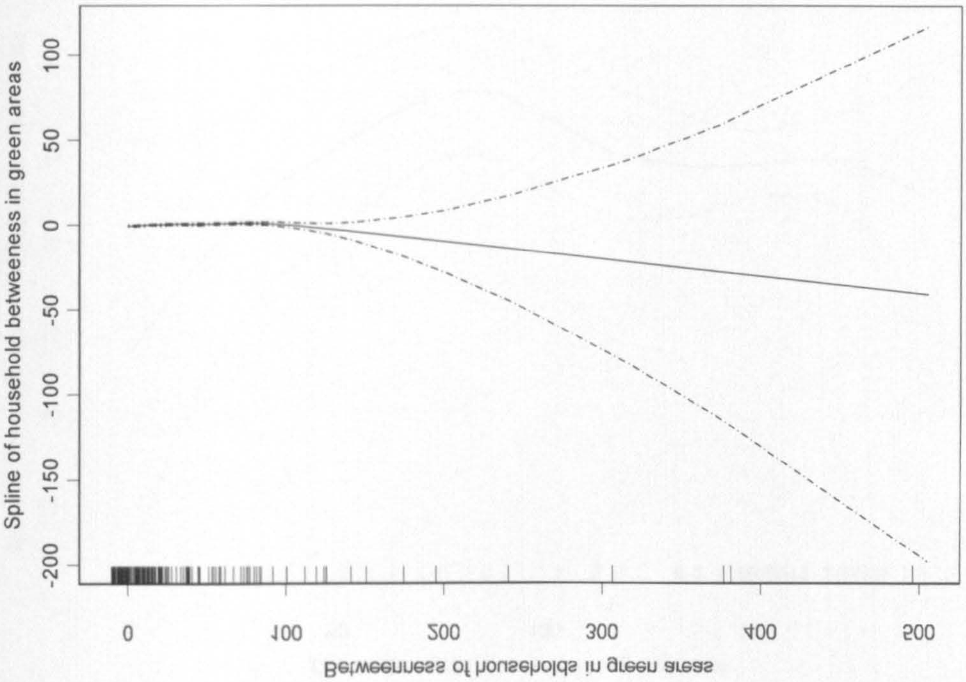


Figure 3. GAM plot of household betweenness per dog for two-mode green areas network (P=0.02).

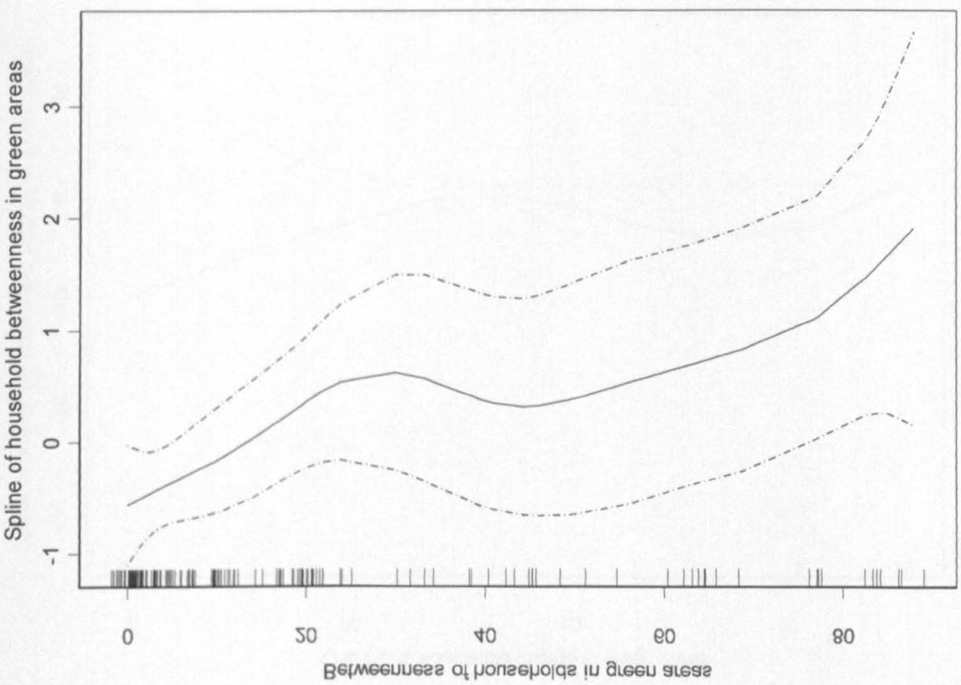


Figure 4. GAM plot of household betweenness per dog for two-mode green areas network, truncated at 100 (P=0.28).

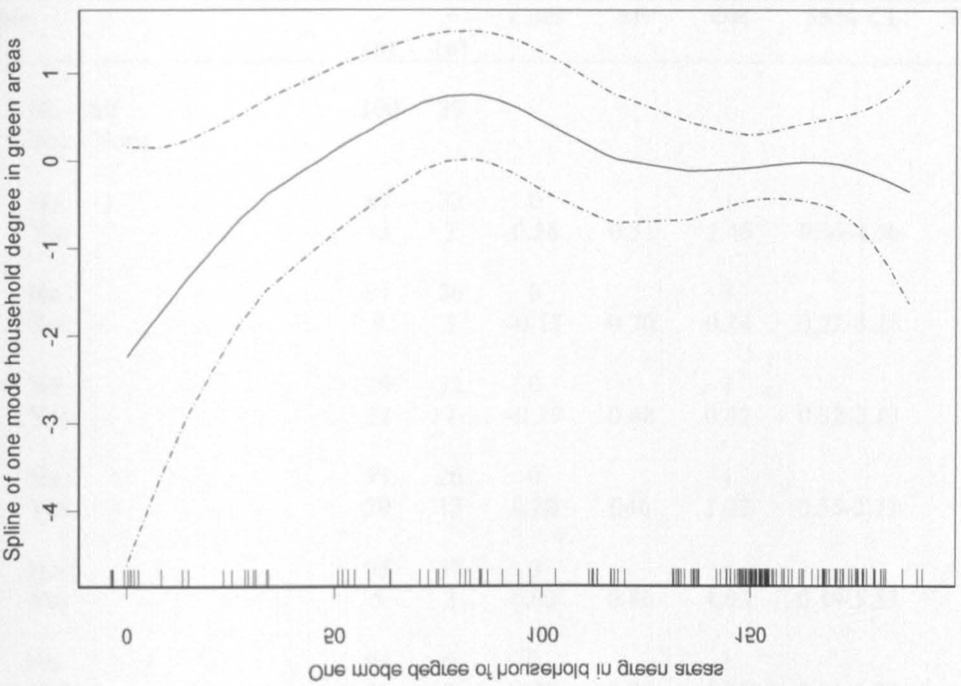


Figure 5. GAM plot of household degree per dog for one-mode green areas network (P=0.04).

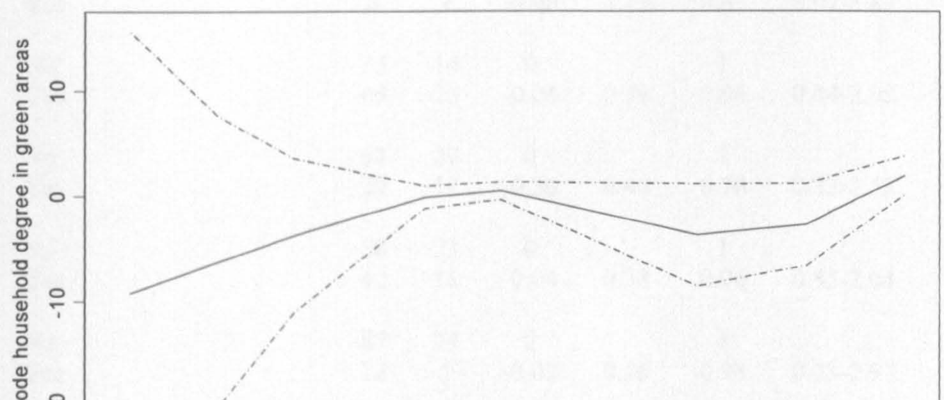


Figure 6. GAM plot of household degree per dog for one-mode green areas network, truncated at 75 (P=0.26).

Table 9. Univariable analysis of household *C. upsaliensis* status (n=139, no known positive dog vs at least one positive dog) for walking in each green area.

Variable		- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
GA1								
	No - All	100	39					
	Yes - None							
GA2								0.46
	No	87	32	0		1		
	Yes	13	7	0.38	0.51	1.46	0.54-4.00	
GA3								1.0*
	No	91	36	0		1		
	Yes	9	3	-0.17	0.70	0.84	0.22-3.29	
GA4								0.69
	No	79	32	0		1		
	Yes	21	7	-0.19	0.48	0.82	0.32-2.13	
GA5								0.62
	No	71	26	0		1		
	Yes	29	13	0.20	040	1.22	0.55-2.71	
GA6								1.00*
	No	95	37	0		1		
	Yes	5	2	0.03	0.86	1.03	0.19-5.53	
GA7								0.71*
	No	94	6	0		1		
	Yes	36	3	0.27	0.73	1.31	0.31-5.50	
GA8								
	No - All	100	39					
	Yes - None							
GA9								1.00*
	No	96	38	0		1		
	Yes	4	1	-0.46	1.13	0.63	0.07-5.83	
GA10								0.92
	No	35	14	0		1		
	Yes	65	25	-0.04	0.39	0.96	0.44-2.08	
GA11								0.37
	No	61	27	0		1		
	Yes	39	12	-0.36	0.40	0.70	0.32-1.53	
GA12								0.92
	No	58	23	0		1		
	Yes	42	16	-0.04	0.38	0.96	0.45-2.04	
GA13								0.98
	No	87	34	0		1		
	Yes	13	5	-0.02	0.56	0.98	0.33-2.97	
GA14								0.07
	No	87	29	0		1		
	Yes	13	10	0.84	0.47	2.31	0.91-5.82	
GA15								0.74
	No	77	29	0		1		
	Yes	23	10	0.14	0.44	1.15	0.49-2.72	
GA16								0.67*
	No	94	37	0		1		
	Yes	6	1	-0.88	1.10	0.41	0.05-3.54	
GA18								0.44*
	No	92	38	0		1		
	Yes	8	1	-1.20	1.08	0.30	0.04-2.50	

*= Fisher's Exact P-value instead of Chi-squared.

Table 10. Univariable analysis of dog *C. upsaliensis* status (n=189) and whether walked in each green area.

Variable		- (n)	+ (n)	Coef	SE	OR	95% CI	P-value
GA1								
	No - All	129	44					
	Yes - None							
GA2								0.24
	No	112	35	0		1		
	Yes	17	9	0.52	0.46	1.69	0.69-4.14	
GA3								1*
	No	117	40	0		1		
	Yes	12	4	-0.03	0.61	0.98	0.30-3.20	
GA4								0.70
	No	102	36	0		1		
	Yes	27	8	-0.17	0.45	0.84	0.35-2.02	
GA5								0.33
	No	95	29	0		1		
	Yes	34	15	0.37	0.38	1.45	0.69-3.02	
GA6								0.42*
	No	124	41	0		1		
	Yes	5	3	0.60	0.75	1.81	0.42-7.93	
GA7								0.72*
	No	122	41	0		1		
	Yes	7	3	0.24	0.71	1.28	0.32-5.16	
GA8								
	No - All	129	44					
	Yes - None							
GA9								1.00*
	No	125	43	0		1		
	Yes	4	1	-0.32	1.13	0.73	0.08-6.68	
GA10								0.93
	No	43	15	0		1		
	Yes	86	29	-0.03	0.37	0.97	0.47-1.99	
GA11								**0.02**
	No	71	33	0		1		
	Yes	58	11	-0.90	0.39	0.41	0.19-0.88	
GA12								0.61
	No	76	24	0		1		
	Yes	53	20	0.18	0.35	1.19	0.60-2.38	
GA13								0.94
	No	112	38	0		1		
	Yes	17	6	0.04	0.51	1.04	0.38-2.83	
GA14								**0.02**
	No	115	33	0		1		
	Yes	14	11	1.01	0.45	2.74	1.14-6.60	
GA15								0.35
	No	100	31	0		1		
	Yes	29	13	0.37	0.39	1.45	0.67-3.12	
GA16								0.68*
	No	122	43	0		1		
	Yes	7	1	-0.90	1.08	0.41	0.05-3.39	
GA18								1.00*
	No	120	41	0		1		
	Yes	9	3	-0.02	0.69	0.98	0.25-3.78	

*= Fisher's Exact P-value instead of Chi-squared.

Table 11. Comparison of culture positives with PCR only positives.

Variable		Cult (n)	PCR only (n)	Coef	SE	OR	95% CI	P-value
Number of dogs								0.12*
	Single dog	21	8	0		1		
	Multiple dogs	16	1	-0.18	1.11	0.16	0.02-1.45	
Lives with a + dog								0.67*
	No	26	8	0		1		
	Yes	9	1	-0.02	1.13	0.36	0.04-3.30	
Fish								0.13*
	No	27	4	0		1		
	Yes	10	5	1.22	0.77	3.37	0.75-15.15	
Presence of 5yrs old or under								1*
	No	34	8	0		1		
	Yes	3	1	0.35	1.22	1.42	0.13-15.47	
Presence of 6-19yr old								**0.03***
	No	24	2	0		1		
	Yes	13	7	1.87	0.87	6.46	1.17-35.74	
Kennel club breed type								
	Cross	10	1					
	Gundog/hound	6	3					
	Pastoral	6	2					
	Terrier	3	0					
	Toy/utility	4	2					
	Unrecognised	6	1					
	Working	2	0					
Size								0.78$
	Toy/small	16	4	0		1		
	Medium	9	3	0.29	0.87	1.33	0.24-7.34	
	Large/giant	12	2	-0.41	0.95	0.67	0.10-4.26	
Approx age years								0.22
				0		1		
	Continuous variable			-0.16	0.14	0.85	0.64-1.12	
Approx age years								1*
	Less than 3 yrs	11	2	0		1		
	3 yrs or older	24	4	0.09	0.94	0.92	0.15-5.78	
Vomiting in past year								0.39*
	No	22	3	0		1		
	Yes	10	3	0.79	0.90	2.20	0.38-12.87	
Diarrhoea in past year								0.37*
	No	18	5	0		1		
	Yes	14	1	-1.36	1.15	0.26	0.03-2.46	
Antibiotic use in past year								0.65*
	No	22	5	0		1		
	Yes	10	1	-0.82	1.16	0.44	0.05-4.27	
Flea treatment in past 3 months								0.72*
	No	17	3	0		1		
	Yes	20	5	0.35	0.80	1.42	0.29-6.81	
Worm treatment in past 3 months								0.28*
	No	13	5	0		1		
	Yes	24	4	-0.84	0.75	0.43	0.10-1.90	
Licks face of visitors								0.40*
	Never/rarely	22	7	0		1		
	Sometimes/often	12	1	-1.34	1.13	0.26	0.03-2.39	

Table 11 (continued). Comparison of culture positives with PCR only positives.

Variable	Cult (n)	PCR only (n)	Coef	SE	OR	95% CI	P-value
Licks face of household members							0.11*
Never/rarely	18	7	0		1		
Sometimes/often	17	1	-1.89	1.12	0.15	0.02-1.36	
Rolls in faeces/carcasses							0.26*
Never/rarely	25	4	0		1		
Sometimes/often	12	5	0.96	0.76	2.60	0.59-11.49	
Fed human food tit-bits							**0.02***
No	1	3	0		1		
Yes	36	6	-2.89	1.24	0.06	0.00-0.63	
Fed raw meat							0.66*
Never	28	8	0		1		
Rarely/sometimes	9	1	-0.94	1.13	0.39	0.04-3.55	
Eat dog faeces							0.17*
Never/rarely	35	7	0		1		
Sometimes	2	2	0.61	1.08	5.00	0.60-41.71	
Use of shovel for garden faeces							0.14*
No	26	4	0		1		
Yes	10	5	1.18	0.77	3.25	0.72-14.62	
Pick up after dog in countryside							0.07*$
Never/rarely/sometimes	14	0					
Usually/always	20	7					
Walk in parks							0.13*
No	20	2	0		1		
Yes	15	7	1.54	0.87	4.67	0.85-25.75	
Walk in farmland							0.17*
No	27	9					
Yes	8	0					
Walk frequency							0.13$
Several times a week or less	12	6	0		1		
Once a day	10	2	-0.92	0.92	0.40	0.07-2.44	
Twice a day or other	15	1	-2.01	1.15	0.13	0.01-1.26	
Walk regularly in a group with friends							0.26*
Never/rarely	15	6	0		1		
Sometimes/often/everyday	21	3	-1.03	0.78	0.36	0.08-1.66	

*= Fisher's Exact P-value instead of Chi-squared.
$ = but 1 or more cells with expected counts less than 5.

CHAPTER SIX

AN OBSERVATIONAL STUDY OF DOGS ON WALKS – INTERACTIONS WITH OTHER DOGS, PEOPLE AND THE ENVIRONMENT.

ABSTRACT

Pet dogs have opportunities to interact with the environment, people and other dogs whilst they are being walked. It is possible that diseases may be transmissible through these contacts. Previously the nature and sequence of these interactions has been studied, but not the frequencies and durations at which they typically occur. This study observed focal dog behaviour of pet dogs being walked in popular park/beach walking areas. Interactions with the environment were recorded including duration spent sniffing, and frequency of urination and defaecation. The frequency and duration of interactions with other dogs and frequency of interactions with people were also investigated.

Descriptive analysis suggested that use of the lead may reduce the number of interactions. Interactions with people were much rarer than interactions with dogs. A multivariable model of percentage duration spent sniffing suggested that day, UK Kennel Club Breed Type and observing urination all affected whether sniffing was observed, with Gundogs the type of dog observed to sniff most. Data was also collected on the number of owners and numbers of other dogs being walked with the focal dog. This suggested that multiple owners were more often seen at weekends rather than weekdays, and multiple dog groups on weekdays and more commonly in the mornings.

6.1 INTRODUCTION

Many dogs interact closely with other dogs whilst out walking, through behaviours such as sniffing, play and aggression. These interactions are beneficial socially and stimulatorily for the dogs and may enhance welfare, but they could also be considered to present a risk of infectious disease transmission between dogs. Dogs may also investigate excretions and alternative food sources whilst on a walk and these may also be a disease risk. In addition dogs may contact people other than their usual household members, such as other dog walkers, and may interact with them.

Although the ways in which particular dogs interact with the environment, people and other dogs whilst out walking may be well known to observant dog owners, there has been little scientific research into this area. Visual communication appears to play little part in many dog-dog interactions, most likely as signalling structures have been modified between breeds, so making visual signalling difficult (Bradshaw and Nott 1995). Previous research has recorded the behaviour sequences that occur during dog-dog interactions in popular walking areas (Bradshaw and Lea 1992). After an initial approach phase, the majority of interactions consisted of olfactory inspections, in particular of the head and anal regions. Female dogs were more likely to concentrate on the head area, and males the anal area, of the other dog. However, this study was limited to two sites in Hampshire, and did not investigate how frequently the interactions occur, which is likely to be important in terms of disease transmission risk to the individual and subsequently through a population. Opportunities for interactions may be affected by human preferences such as walk frequency and on/off lead preferences, the walking environment, and individual dog behaviours and type.

This study focused on investigating the frequency of contact with other people and other dogs, and interactions with the environment such as sniffing or defaecating, whilst being walked in a popular outdoor environment. Interactions of the dog with the owner or with other dogs that they live with were not investigated as it can be assumed that there is extensive contact between these individuals in the home environment. It is also likely that dogs behave differently during interactions with familiar people or dogs than with strangers. Three popular dog-walking areas in the Wirral region of Cheshire/Merseyside were used; West Kirby Beach (WK), Royden Park (RP) and a sports field in Parkgate, Neston (PG). These locations had been identified in a previous questionnaire survey of dog owners in a nearby area (Chapter 3).

Sniffing the ground was chosen as a behaviour to investigate further as it was common and would be expected to be influenced by a number of other factors. Dogs cannot be sniffing at the same time as performing the other behaviours studied and therefore whether there are any other behaviours available such as interacting with dogs may influence the amount of sniffing seen. In addition, sniffing may be likely to occur before urination and defaecation.

6.2 METHODS

6.2.1 Data collection areas and times

In each of the three areas an observation point, such as a park bench, was selected and an observation area defined in which a dog could be observed easily by eye without often going out of sight. All three areas were chosen for being a significant but not vast open space, large enough to observe a dog for a satisfactory period but keeping the dog within a distance to be observed effectively. Popular times of day for dog walking had been identified in a previous questionnaire study in a nearby community (Chapters 3 and 4). The study areas were visited for two-hour study periods approximating 8-10am, 3-5pm and 5.30-7.30pm on week days and 10-12am, 1-3pm and 3.30-5.30pm on weekend days. Each of the three study areas was visited alternately for each of these observation periods across three week days (Tuesday Thursday, Friday) and three weekend days (Saturday 1, Saturday 2, Sunday) in September 2006. Days with predicted good weather were used in order to maximise the number of dogs that could be observed, but some showers were experienced. From pilot studies it was estimated that 8-10 dogs could be observed per hour, and the study aimed to collect data on approximately 300 dogs.

6.2.2 Focal dog observation method

The focal sampling method of observation was chosen (Martin and Bateson 1993a). All observations were conducted by one person (CW). The dog in a dog-owner unit was observed as it entered the study area, until the time the dog exited the area or 10 minutes had elapsed. Once a dog had left the study area the next observation was started once the next dog-owner unit had entered the area. For dog-owner units with more than one dog, only one dog was chosen for observation; the first or second dog was sampled for each alternate unit, to avoid potential bias. If the dog being observed had been observed previously in the current two-hour session, or could distinctly be remembered as being observed on a previous occasion, this dog was recorded as seen before.

It was assumed that dogs and owners walking together belonged to the same household; although this may not be strictly true, it was assumed that if dogs and owners regularly meet to walk then they have substantial contact with each other under normal circumstances, similar to contact within households. Behaviours of each focal dog were recorded using Noldus Pocket Observer XT software (Noldus 2004, 2006) on a Psion Workabout Pro handheld (Psion Teklogix 2006) and then uploaded on to a desktop computer for analysis.

6.2.3 Ethogram

Behaviour patterns (behaviours) recorded are presented in Table 6.1. State behaviours in a single class were mutually exclusive. An interaction with a person was defined as a physical contact seen (or almost physical contact) such as jumping up, sniffing, or a person patting the dog. An interaction with another dog was defined as the dogs being in close physical proximity and attention focused on each other, for example sniffing each other, or a bout of play, including chasing each other (even though the dogs may not be in actual physical contact at this point, aerosol transmission might occur). Note that interactions between dogs were classed as states (and would therefore have a duration) whereas an interaction between a dog and a person were recorded as an event. This was so that it would be possible to record, for example, a person patting a dog whilst it was sniffing a dog.

For each observation the independent variables recorded were day, time, location, number of dogs in unit, number of owners in unit, type of owners (e.g. male, female or child), type of dog, gender of dog, and whether the dog had been observed before. Dog types were later classed into UK Kennel Club categories, crossbreed, or unknown (including some breed types that are difficult to identify accurately). For the purposes of this study, Jack Russell and Patterdale Terriers are classed as Terriers, even though they are not actually recognised by the UK Kennel Club.

Table 6.1 Ethogram of behaviours recorded.

Behaviour	State or event	Description	Modifier
Lead class			
On lead	S	On lead	
Off lead	S	Off lead	
Interaction class			
Sniffing ground	S	Sniffing the ground whilst standing still or moving slowly	
Null state	S	Any other behaviour	
Interacting with dog	S	Play, sniffing, aggression etc.	Dog 1,2,3….
Interacting with person	E	Patted, jumps up, given a treat etc.	Person 1,2,3…. Or observer
Approached observer	E	Approached observer	
Defaecate	E	Defaecated	
Picked up	E	Owner picked up faeces	
Urinate	E	Urinated	
Roll	E	Roll on ground	
Eat	E	Eating, chewing or drinking	
Unobserved	Suspend and resume	Subject is out of sight	

6.2.4 Data analysis

Associations between variables were analysed in Minitab (Minitab.Inc 2005) using Chi-squared, Kruskal-Wallis and Mann-Whitney Tests, as appropriate. Spearman's rank correlations in SPSS were used to assess associations between continuous variables. Sniffing durations (seconds) and percentage durations were log transformed as they were non-normal distributions and a high proportion of the values were zero. To avoid issues with log transformation of zero values, 1 was added to each duration prior to transformation. Factors associated with percentage of time spent sniffing the ground were identified using regression analysis. Then, a multivariable model of percentage time spent sniffing the ground was built using stepwise backward elimination using those variables identified as $P<0.3$ during univariable analysis.

6.3 RESULTS

6.3.1 Number of observations

In total, 302 observations were recorded over six days of sampling. Sixteen observations (5%) had to be excluded due to technical difficulties with the software. This occurred when the dog repeatedly went out of sight of the observer, for example sniffing in bushes at the edge of the observation area, or behind a tree. There was no problem with data recording if the dog performed some behaviour change between out of sight periods. However, if the behaviour stayed the same between out of sight periods, then data was lost and the observation had to be excluded from analysis[1]. No significant differences were detected using Chi-squared and Fisher's Exact tests, between the 16 excluded observations and the others, in terms of: location, day, gender of dog, and whether it had been seen before. The following results are for the 286 observations used for analysis only. Of the 286 observations included in the analysis, 23 (8%) of the observations were identified as repeat on a dog previously observed (seen before, usually that day but a very few were also recognisable as observed a previous day).

6.3.2 Independent variables

The percentage of observations recorded on each of the six days varied from 15 to 20%, with a weekday (Tuesday) having the most data collected. Forty-eight percent of the observations were on a weekend day compared to weekday. Seventeen percent of the observations were collected between 8am and 9.59am (though this time was not sampled on weekend days), 17% 10-11.59am (weekend only), 19% 1-2.59pm, 26% 3-4.59pm and 22% 5-7.30pm (again some of this time was not sampled at weekends). Parkgate provided 30.4% of the observations, Royden Park 38.8% and 30.8% were at West Kirby Beach. For most observations the weather was recorded as sunny (70.3%) but there was also some cloud (23.8%) and rain (5.9%).

Most dogs (69%) were being walked on their own, 24% of owners had two dogs, 4% three dogs, up to a maximum of 8 dogs. The majority of the dogs were observed with one owner (59%), 30% with two owners, 7% three owners and up to a maximum of 6 owners. Two dogs entered the study area and were observed without any sign of an owner. Single male, and single female owners accounted for 29% and 30% of observations respectively, with a further 21% being walked by a pair consisting of one male and one female. A child was present in 9% of the observations. The most popular type of dog seen was the Labrador Retriever (14%) followed closely by crossbreed types (13%) and Collie (11%). Gundogs (32%) were the most popular of the UK Kennel Club breed types. For 14 dogs (5%) the type was classed as unknown. For most dogs the sex was not clearly identified during the observation period (75%), of the rest 14% were identified as male and 12% as female.

[1] This arose due to a problem with the software; we have been informed that this function has never worked suitably and will be removed from the software in future versions.

The duration of the observations varied from 10-600 seconds, with a median of 136 seconds and mean of 180 seconds (Fig.6.1). Six hundred seconds corresponds to the 10 minutes automatic cut-off time for the observation length.

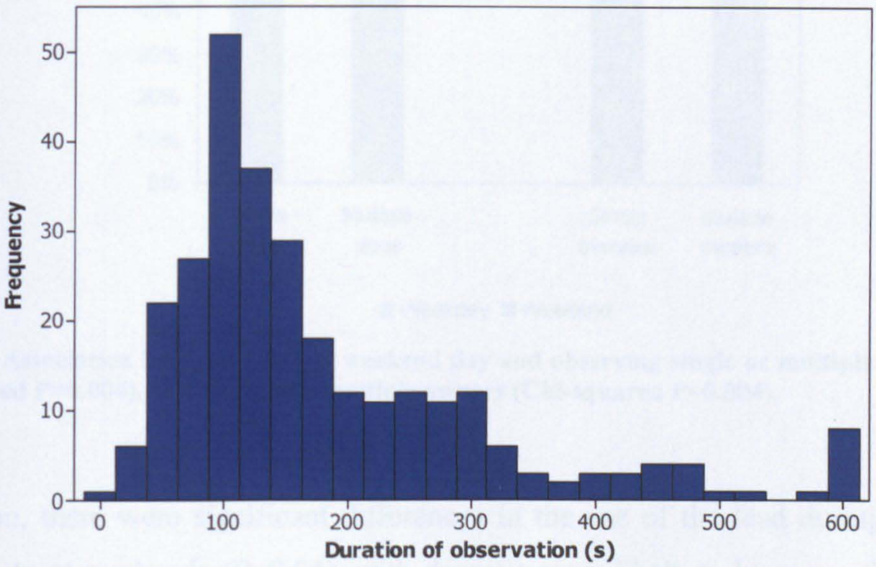


Figure 6.1. Histogram of duration of observation (n=286).

Associations between independent variables

Weather and weekend were significantly associated (P<0.001), with a tendency towards sunny weekdays and cloud or rain at weekends. Weather varied with location (P<0.001) and was also significantly associated with time of observation (P<0.001), to be expected as it rained at a certain point in time on one day. Multiple owners were more likely to be seen when it was cloudy or rainy compared to sunny (P=0.02). This is probably due to the effect of different weather at weekends at this time. There was also a significant difference in use of the lead during different weathers (P=0.01), with more dogs seen off lead when it is sunny, but group sizes were small.

Sampling day was significantly associated with single versus multiple dogs in the observation unit (P=0.03) most likely because weekday or weekend was also significantly associated with single vs multiple dogs (P<0.01) with more single dogs at weekends (Fig.6.2). In contrast, dogs were more likely to be walked with multiple owners at weekends, compared to during the week (P<0.01, Fig.6.2).

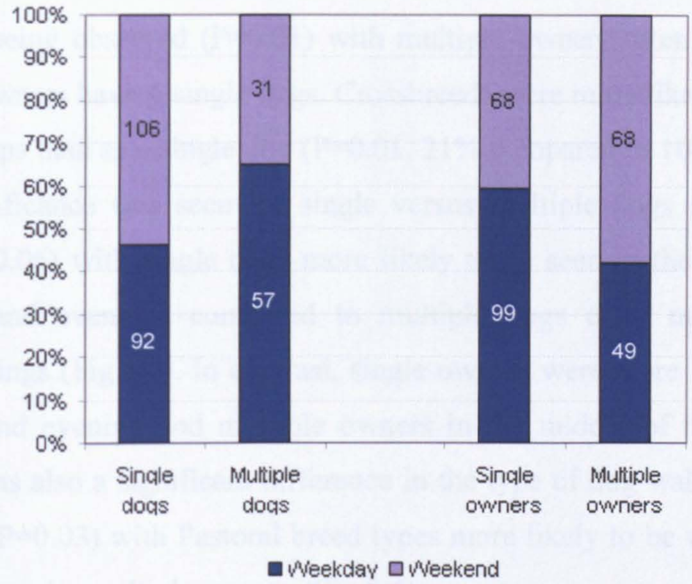


Figure 6.2 Association between week or weekend day and observing single or multiple dogs in unit (Chi-squared P=0.004), and single and multiple owners (Chi-squared P=0.004).

In addition, there were significant differences in the use of the lead during the week compared to at weekends (P=0.04), with dogs (i) more likely to be seen off lead only (73% and 59% respectively); (ii) less likely to be observed on lead only (11% and 18%); and (iii) less likely to be seen both on and off lead (16% and 23%). It was not possible to assess whether all these findings were also applicable to variation in individual days, due to some low numbers when categorising by 6 days compared to simply weekday or weekend. As data collection times were slightly different on weekdays and weekend days, it was not possible to assess the effect of time on these variables.

There was a significant difference in the number of dogs seen at different locations (P<0.01) with higher numbers of three or more dog groups seen at Parkgate. However, this association was not significant when comparing multiple dog groups versus single dogs. Use of the lead also varied with location (P=0.001) with off lead only being seen more frequently at Parkgate than the other locations (79% compared to 69% RP and 50% WK). The type of dog seen at the locations approached significance (P=0.06) with West Kirby having the least proportion of recognised breeds (80%, versus crossbreeds 20%) and Parkgate the highest proportion of recognised breeds (92% versus 8%).

There was a significant association between the number of owners and number of dogs seen in the unit being observed (P=0.01) with multiple owners often having multiple dogs and single owners having single dogs. Crossbreeds were more likely to be found in multiple dog groups than as a single dog (P=0.01, 21% compared to 10%). A difference approaching significance was seen for single versus multiple dogs seen at different times of day (P=0.06) with single dogs more likely to be seen in the late morning to early afternoon and evenings compared to multiple dogs early morning and late afternoon to evenings (Fig.6.3). In contrast, single owners were more likely to be seen in the morning and evening and multiple owners in the middle of the day (P<0.01, Fig.6.3). There was also a significant difference in the type of dog walked by single vs multiple owners (P=0.03) with Pastoral breed types more likely to be walked by single owners and toy types by multiple owners (Fig.6.4).

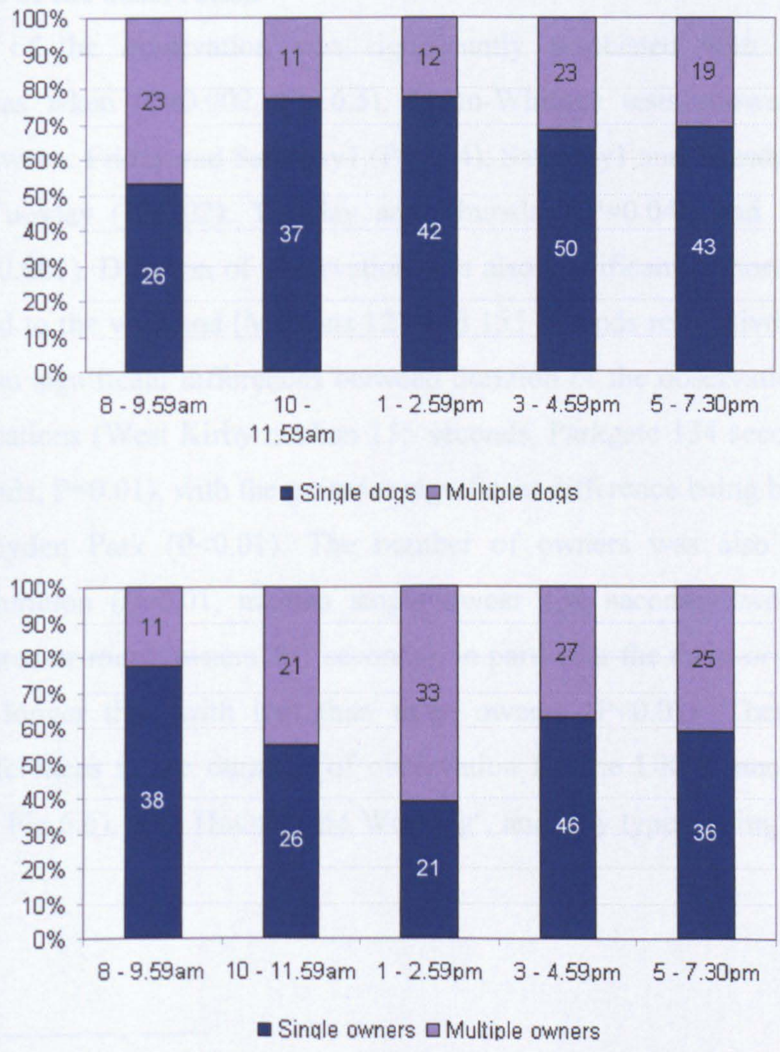


Figure 6.3 Association between number of dog/owners in unit and time of day (Chi-squared P=0.06 and P=0.002 respectively).

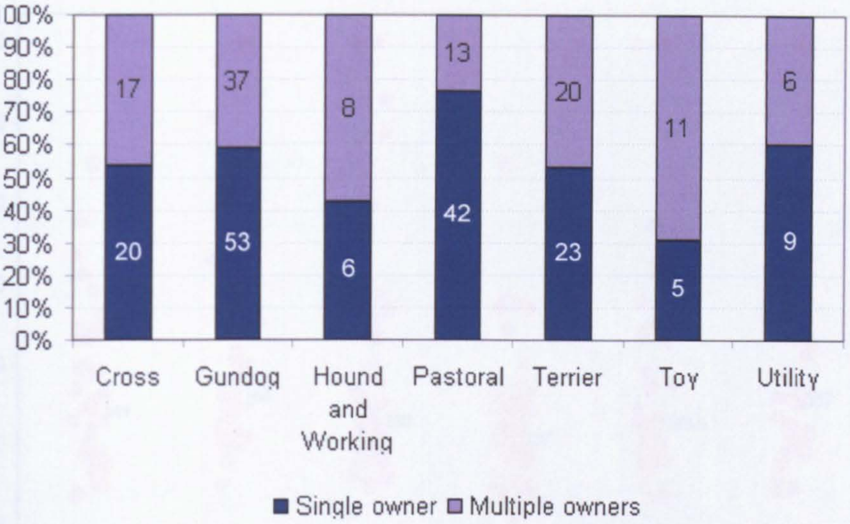


Figure 6.4 Association between number of owners in unit and type of dog (Chi-squared P=0.03).

6.3.3 Duration of the observation

The duration of the observation was significantly associated with the day the observation was taken (P=0.002, Fig.6.5). Mann-Whitney tests showed significant differences between: Friday and Saturday1 (P=0.04); Saturday1 and Tuesday (P<0.001); Sunday and Tuesday (P=0.02); Tuesday and Thursday (P=0.04); and Tuesday and Saturday2 (P=0.001). Duration of observation was also significantly shorter during the week compared to the weekend (Medians 127 and 155 seconds respectively, P=0.001). There were also significant differences between duration of the observations observed in different locations (West Kirby median 155 seconds, Parkgate 134 seconds, Royden Park 121 seconds, P=0.01), with the pairwise significant difference being between West Kirby and Royden Park (P<0.01). The number of owners was also significantly different by duration (P=0.01, median single owner 134 seconds, two-owners 121 seconds and three-or-more owners 201 seconds), in particular the three-or-more owners groups being longer than with less than three owners (P<0.01). There were also significant differences in the duration of observation for the UK Kennel Club breed types (P=0.04, Fig.6.6), with Hounds and Working[2], and Toy types, being observed for longer periods.

[2] Hounds and Working categories had been combined due to low numbers. If analysed separately these has a median duration of 247 and 244 seconds respectively, still both high. However, due to the now low numbers these differences across the groups were now not significant (P=0.1).

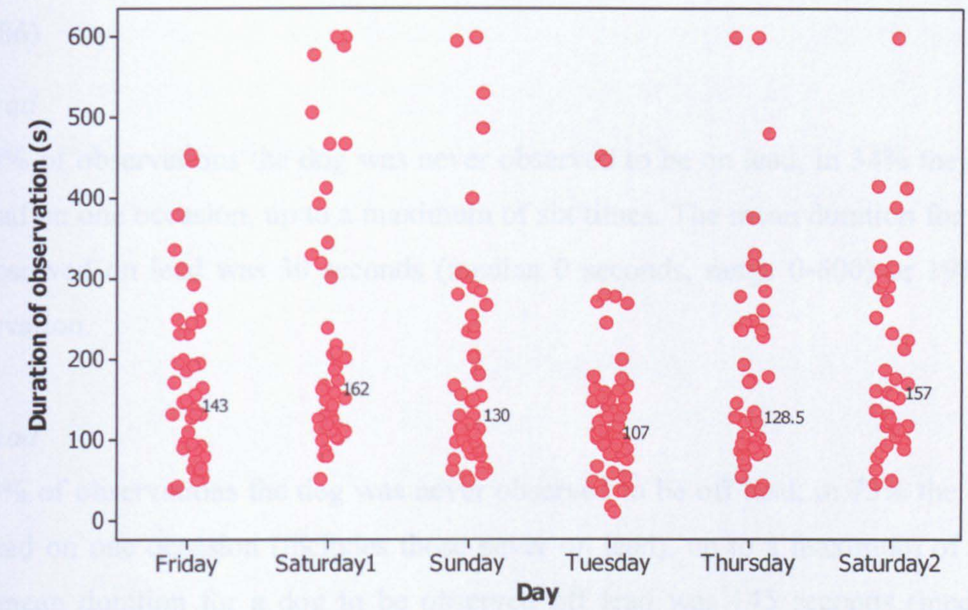


Figure 6.5 Individual value plot of duration of observation (and medians) for day of the week.

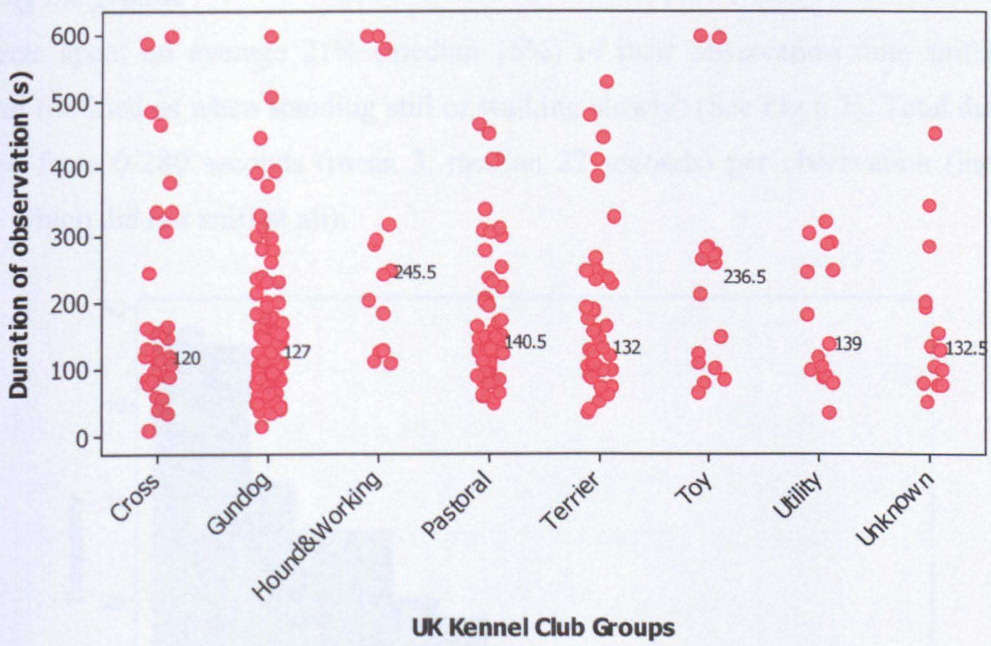


Figure 6.6 Individual value plot of duration of observation (and medians) for UK Kennel Club groupings.

6.3.4 Descriptive statistics of behavioural data for all analysable observations (n=286)

On lead

In 66% of observations the dog was never observed to be on lead, in 34% the dog was on lead on one occasion, up to a maximum of six times. The mean duration for a dog to be observed on lead was 30 seconds (median 0 seconds, range 0-600) or 19% of the observation.

Off lead

In 14% of observations the dog was never observed to be off lead, in 73% the dog was off lead on one occasion (includes those never on lead), up to a maximum of 4 times. The mean duration for a dog to be observed off lead was 145 seconds (median 120 seconds, range 0-600) or 81% of the observation.

Sniffing the ground

Subjects spent on average 21% (median 16%) of their observation time sniffing the ground (defined as when standing still or walking slowly) (See Fig.6.7). Total durations ranged from 0-280 seconds (mean 3, median 22 seconds) per observation (including those which did not sniff at all).

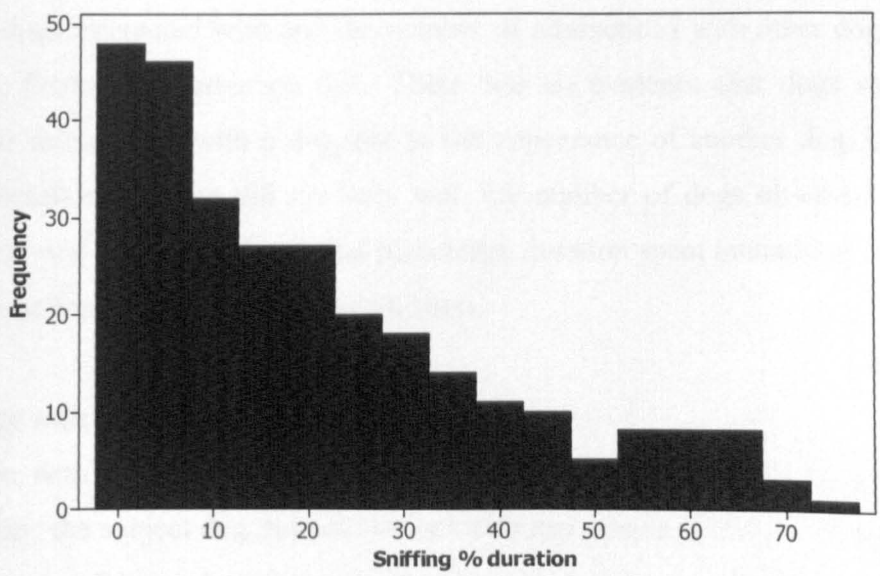


Figure 6.7 Histogram of sniffing percentage duration.

A sniffing episode was recorded on average 6.5 times per observation (median 5, range 0-46) at a mean rate of 2.5 (median 2.0) times per minute. The individual sniffing episode length per observation was on average 5 seconds (median 4, range 0-26). There was no evidence that sniffing duration differed by location, but there were significant differences seen in the mean sniffing episode length (P=0.04, medians PG 4.9s, RP 4.4s and WK 3.9s respectively).

Interacting with dogs other than those within the group being walked together

In most observations no dog-dog interactions occurred (73%). Interactions with one other dog were observed in 21%, two dogs 4%, up to a maximum of 8 different dogs. Subjects interacted with on average 0.4 dogs per observation, at a mean rate of 0.1 dogs per minute (max 1.4). Even at the average rate this equates to 7.2 dogs met per hour walk. On average 0.7 dog-dog interactions were recorded per observation (range 0-18), at a mean rate of 0.2 per minute (range 0-3.9). Subjects spent on average 0.02% of their observation time interacting with other dogs. Total duration spent interacting with other dogs ranged from 0-185 seconds (mean 5, median 0 seconds) per observation. The mean interaction length was on average (per observation) 2 seconds (median 0, range 0-31 seconds).

As would be expected, a significant association was seen between the number of different dogs interacted with and the number of interactions with other dogs observed ($P<0.001$, Pearson's correlation 0.9). There was no evidence that dogs were cutting short their interactions with a dog due to the appearance of another dog, because the mean interaction duration did not vary with the number of dogs observed to interact with. There was also no evidence that percentage duration spent interacting with dogs or mean interaction duration differed by location.

Interacting with people

Interaction with people was less commonly seen than interactions with dogs. In most observations the subject dog did not interact with any people (91%), 7% one person, up to a maximum of 3 people. A physical contact with the observer (sniffing/nudging with nose or jumping up) was included as an interaction with a person, although the observer ignored the dog (see below). On average, subjects were observed to interact with 0.13 people, at a mean rate of 0.04 people per minute (max 1.4), equating to an average of

2.4 people per hour walk. A maximum of 16 interactions with people were recorded per observation (mean 0.3 interactions) at a mean rate of 0.1 per minute (maximum 3.1).

Approaching observer

Twelve subjects approached the observer once, and two twice, during their observation period. Only two approaches resulted in an actual physical contact.

Other events

Most subjects (89%) were not observed to defaecate, 10% once, up to a maximum of three times in an observation (mean 0.1). Defaecation occurred at a mean rate of 0.04 per minute of observation (max 1.2). In 63% of observations all faeces deposited were picked up, in 28% no faeces were picked up. In the remainder, the owner was observed to pick up faeces following some, but not all, of the defecation events. Urination was observed in 37% of observations, up to a maximum of 7 times per observation (mean 0.6, median 0). Subjects urinated at a mean rate of 0.2 per minute of observation (max 2.5). Eating was only recorded in 6 observations, maximum 4 times in one observation. Rolling behaviour was observed in 8 observations, up to a maximum of 4 times in one observation.

6.3.5 Exploratory analysis

Duration of observation

The duration of the observation was significantly associated with many other variables, as the longer a subject was observed the more chance there was of observing it performing a behaviour. There was a significant correlation between the log transformed sniffing duration and duration of the observation ($P<0.001$, Spearman's rank correlation coefficient 0.45, Fig.6.8). However no correlation was seen when comparing with percentage duration of sniffing ($P=0.75$, Spearman's rank correlation coefficient 0.02, Fig.6.9).

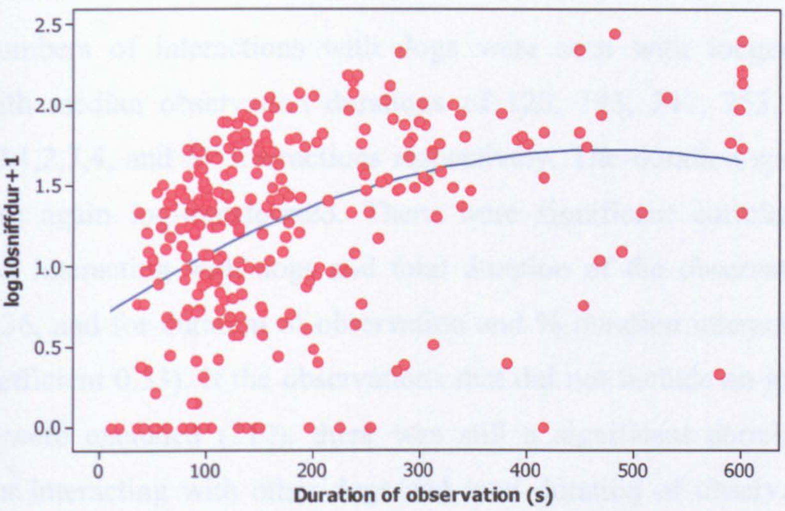


Figure 6.8 Scatterplot of sniffing duration against duration of observation.

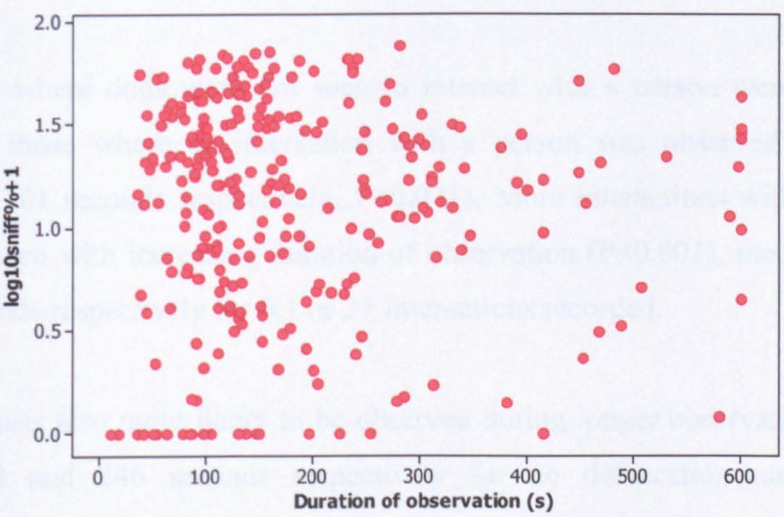


Figure 6.9 Scatterplot of percentage of time spent sniffing against duration of observation.

The duration of the observation was also significantly associated with the use of the lead (P<0.001). For 20% of the observations the dog was observed both off and on lead during the observation. All three pairwise combinations of on only, off only and both, had significantly different median durations (P<0.02); the median durations were 98, 137 and 182 seconds for on only, off only and both respectively.

There was a significant difference in duration of observation for those dogs who were not seen to interact with another dog compared to those who did (medians 120 seconds and 219 seconds respectively, P<0.001). When categorised by the number of different dogs it interacted with (0,1,2+) this was also significant (P<0.001, medians 120, 231 and 205 respectively).

Increasing numbers of interactions with dogs were seen with longer observations ($P<0.001$) with median observation durations of 120, 193, 241, 253, 253 and 390 seconds for 0,1,2,3,4, and 5+ interactions respectively. The duration spent interacting (and %) were again log-transformed. There were significant correlations between duration spent interacting with dogs and total duration of the observation ($P<0.001$, coefficient 0.36, and for duration of observation and % duration interacting with dogs ($P<0.001$, coefficient 0.33). If the observations that did not include an interaction with another dog were excluded (210), there was still a significant correlation between duration spent interacting with other dogs and total duration of observation ($P=0.01$, coefficient 0.30) but this was removed by using percentage duration instead ($P=0.09$, coefficient -0.20).

Observations where dogs were not seen to interact with a person were significantly shorter than those where an interaction with a person was observed (Median 129 seconds and 301 seconds respectively, $P<0.001$). More interactions with people were likely to be seen with increasing duration of observation ($P<0.001$), medians 129, 193 and 304 seconds respectively for 0,1 or 2+ interactions recorded.

Defaecation was also more likely to be observed during longer observations ($P<0.001$, medians 128 and 246 seconds respectively for no defaecation and defaecation observed). Urination was more likely to be observed during longer observations, but not significantly ($P=0.14$). Eating was more likely to be observed during longer observations ($P=0.002$, Medians 132 and 306 seconds respectively for no eating, and eating observed). Rolling was also more likely to be observed during longer observations ($P<0.001$, Medians 131 and 239 seconds respectively for no rolling, and rolling observed).

Use of the lead

The data was subset according to whether the dog was on or off lead when the behaviour occurred. However, statistical comparisons were not performed for any behaviour other than sniffing, as the other behaviours were not observed frequently enough, and it is not correct to assume that all observations were independent, or either that they were all paired. For example, from descriptive analysis, subjects spent less time sniffing the ground when on lead compared to off lead (Table 6.2). The median percentage duration spent sniffing when off lead was 16% compared to 4% whilst on lead (Mann-Whitney $P<0.001$), although this assumes that all observations are independent. In truth, a fifth of dogs were observed both on and off lead. Alternatively, a truly independent comparison between only those dogs observed in one or other lead states showed a similar trend but only approached significance (median sniffing duration 16% off lead vs 9% on lead, $P=0.09$). If comparisons were performed in only those dogs where both lead states were observed, they spent an average of 10% more time sniffing off lead than on lead (Wilcoxon signed rank test $P<0.001$). When comparing those dogs observed on lead only with those observed in both states, a median of 9% increase was seen ($P=0.001$).

In addition, less time was spent interacting with other dogs when on lead compared to off lead (Table 6.2). When on lead, dogs interacted with fewer dogs and less people compared to when off lead. Also, the mean dog interaction duration was 1.7 seconds when off lead compared to 1.0 seconds when on lead (Table 6.2). However, owners were seen to pick up faeces more often after their dogs had defecated when the dog was on lead (Table 6.3).

Table 6.2 Comparison of off and on lead for states sniffing ground and interacting with other dogs.

State	Rate (number/min)			% Duration			Total duration (seconds)			Mean duration (seconds)		
	Range	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range	Mean	Median
Sniffing ground												
Off lead	0-12.14	2.48	1.97	0-76.03	21.69	16.28	0-267.00	30.36	16.86	0-26.70	4.33	3.52
On lead	0-11.95	2.25	1.29	0-77.69	12.35	4.34	0-166.58	4.80	0.00	0-13.45	0.77	0.00
Interactions with dogs												
Off lead	0-3.86	0.22	0.00	0-43.23	2.58	0.00	0-133.58	3.93	0.00	0-30.66	1.72	0.00
On lead	0-3.05	0.11	0.00	0-33.96	1.58	0.00	0-107.5	0.98	0.00	0-51.59	0.45	0.00

Table 6.3 Comparison of off and on lead for events defaecate, pick up, urinate, roll, eat and interact with a person or dog.

Event	Rate (number/min)			
	Range	Mean	Median	Mean %
Defaecate				
Off lead	0-1.24	0.05	0.00	
On lead	0-0.34	0.01	0.00	
Faeces picked up				
Off lead	0-0.47	0.02	0.00	61.90%
On lead	0-0.34	0.01	0.00	100%
Urinate				
Off lead	0-2.48	0.26	0.00	
On lead	0-1.26	0.08	0.00	
Interactions with people				
Off lead	0-3.13	0.08	0.00	
On lead	0-0.76	0.01	0.00	
Number of people interact with				
Off lead	0-1.39	0.04	0.00	
On lead	0-0.25	0.003	0.00	
Number of dogs interact with				
Off lead	0-1.93	0.14	0.00	
On lead	0-1.83	0.07	0.00	

Interacting with dogs or people combined

There was a significant association between meeting people and meeting dogs (OR 16.7, 95%CI 6.1-46.2). Observations were coded as to whether the dog was observed to interact with neither people nor dogs (72%), dogs only (19%), people only (2%), and both people and dogs (8%). There were possible differences in these proportions by location (P=0.01) although group sizes were small (Fig.6.10). No significant associations were found with other independent variables.

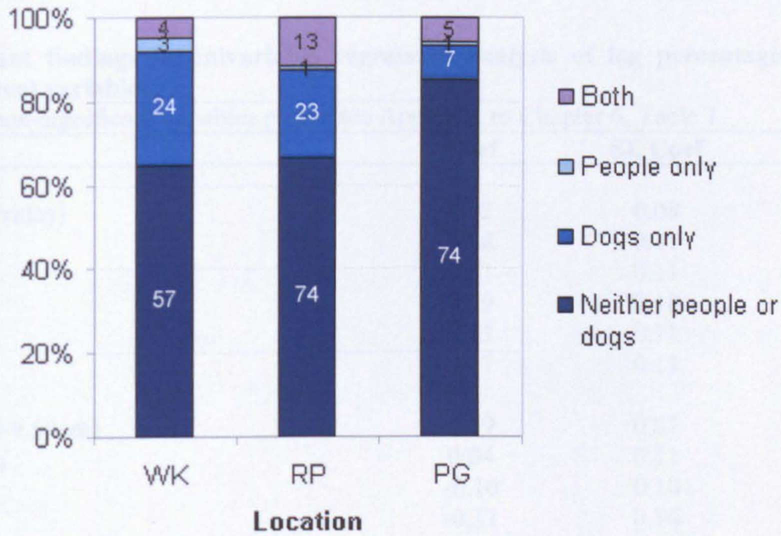


Figure 6.10 Interacting with people and dogs at different locations (WK = West Kirby, RP = Royden Park and PG = Parkgate).

6.3.6 Percentage time spent sniffing the ground explored further

Univariable analysis

To account for the association of duration of observation with time spent performing each behaviour, analysis was performed using percentage duration instead of total duration. Log percentage time spent sniffing was investigated by univariable regression analysis for associations with independent variables of interest (Table 6.4 and Appendix to Chapter 6 - Table 1) and with other behaviours observed (Table 6.5 and Appendix to Chapter 6 - Table 2). There was evidence for a significant association with day of sampling and time of sampling, though these variables are likely associated with each other (P=0.05 for both, Table 6.4). There was also a significant association with type of dog, with gundog types sniffing significantly more than other types (P=0.001, Table

6.4). Whether urination or defaecation behaviours were observed was also associated with increased sniffing seen (P<0.001 and P=0.01 respectively, Table 6.5).

Multivariable model

In the final multivariable model, factors associated with sniffing behaviour included day of observation, Kennel Club Group and urination (Table 6.6). Duration was tested in the model building process but was not deemed important, and use of percentage duration of sniffing seemed sufficient to account for this.

Table 6.4 Significant findings in univariable regression analysis of log percentage time spent sniffing – Independent variables.
For table including non-significant variables please see Appendix to Chapter 6, Table 1.

Variable	Coef	SE Coef	P-value
Day			**0.05**
Constant (Friday)	0.92	0.08	
Saturday 1	0.18	0.11	0.10
Sunday	0.31	0.11	<0.01
Tuesday	0.29	0.10	0.01
Thursday	0.13	0.11	0.24
Saturday 2	0.17	0.11	0.12
Time			**0.05**
Constant (8-9.59am)	1.19	0.07	
10-11.59am	0.04	0.11	0.97
1-2.59pm	-0.10	0.10	0.33
3-4.59pm	-0.11	0.10	0.26
5-7.30pm	-0.24	0.10	0.12
UK Kennel Club Group			**0.001**
Constant (Gundog)	1.27	0.05	
Crossbreed	-0.22	0.10	0.03
Hound and Working	-0.22	0.15	0.14
Pastoral	-0.41	0.09	<0.001
Terrier	-0.17	0.09	0.07
Toy	-0.12	0.14	0.40
Utility	-0.18	0.14	0.21

Table 6.5 Significant findings in univariable regression analysis of log percentage time spent sniffing – Other behaviours.
For table including non-significant variables please see Appendix to Chapter 6, Table 2

Variable	Coef	SE Coef	P-value
Defaecation observed			**0.01**
Constant (No)	1.07	0.03	
Yes	0.27	0.10	0.01
Urination observed			**<0.001**
Constant (No)	0.98	0.04	
Yes	0.34	0.06	<0.001

Table 6.6 Multivariable regression model of log percentage time spent sniffing.

Variable	Coef	SE Coef	P-value
Constant	0.95	0.09	
Day (ref=Friday)			
Saturday 1	0.19	0.11	0.07
Sunday	0.30	0.10	<0.001
Tuesday	0.26	0.10	0.01
Thursday	0.13	0.10	0.23
Saturday 2	0.19	0.11	0.07
Kennel Club Group (ref=Gundog)			
Crossbreed	-0.22	0.10	0.02
Hound and Working	-0.18	0.14	0.21
Pastoral	-0.35	0.08	<0.001
Terrier	-0.20	0.09	0.03
Toy	-0.02	0.13	0.86
Utility	-0.15	0.14	0.29
Urination			
Urination observed yes	0.33	0.06	<0.001

6.4 DISCUSSION

This study has demonstrated that there is large variation between dogs in the behaviours that they perform whilst on a walk. It also highlights interesting owner behaviour when walking their dogs and informs about dog ownership preferences and psychology.

6.4.1 Possible biases

There may have been some bias introduced to the data due to the exclusion of 16 observations. The loss of this data could bias our conclusions against dogs that did not change their behaviour often compared to those who had more varied behaviour. However, no significant differences were detected in the independent variables between the 16 excluded observations and the 286 other observations, using Chi-squared and Fisher's Exact tests, in terms of location, day, gender of dog, and whether had been seen before. It was not possible to test for other variables such as number of dogs in the unit, dog type or owner type due to small group sizes, and this would also have affected the power to assess any differences between the excluded observations and the others.

Observer bias was minimised by a single person collecting the data, but it is likely that if the study was repeated with a different observer, some differences in the results may be seen. It was not possible to perform an assessment of within-observer reliability (Martin and Bateson 1993b), as videoing the dogs was attempted during the pilot phase and deemed an unsuitable method of data collection; behaviours could not be reliably distinguished compared to by eye, due to distance, obstacles and lighting issues. Due to the low number of observations classed as 'seen before', these were included in the analysis. However, it is possible that duplication of some subjects may have influenced the data, but it is unlikely to have had a major effect. It is possible that the presence of the observer had an effect on the subjects (Martin and Bateson 1993c), but this could not be avoided and the observer remained as inconspicuous as possible. It was also not possible to blind the observer as to whether the dog was on or off lead during data collection (Martin and Bateson 1993c), and this can introduce bias.

Of course it must also be remembered that these data were collected in three walking areas only and some differences are likely to occur depending on the environment. In addition, these areas may have between themselves differed in the positioning of the stage of the walk for the dogs, for example whether dogs were often observed at the beginning or end of their walks. This is likely to affect the types of behaviours observed. However, dogs were observed entering and exiting the areas from various sides, and it has been suggested in one study that dog behaviour differs little between when they are first let free, in intermediate segments and on completion of their walks (Bekoff and Meaney 1997). It is difficult to assess the evidence supporting this suggestion due to limited description in the publication. Behaviour of both owners and dogs may vary due to weather and season and only days of predicted good weather were used and over a short time period of two weeks in the month of September, and therefore results can only be deemed representative of this situation.

6.4.2 Number of dogs in a group

Approximately two-thirds of subjects were single dogs, with fewer in two-dog groups and even fewer three-dogs or more. It is likely that some of the dogs in groups were not actually owned together but had different owners who were walking together at that moment. This situation could not be consistently distinguished and so the assumption was made that they were from the same household. The proportions of one-, two- and three-dog groups observed did approximate that reported as owned in the questionnaire survey in a nearby community (Chapter 2); this supports the use of the assumption that dogs walking together are owned together. However, multiple dogs tended to be observed with multiple owners, which could be explained by larger families having more dogs, or dogs and their owners that were walking together in groups. There was an elderly owner who has been repeatedly observed walking a large group of dogs (7) during study design and data collection and was thought to be the owner of all the dogs.

Proportionally more multiple-dog groups were observed on weekdays compared to weekends, when single dogs were more likely to be observed. It may be that people with more than one dog have time to walk the dogs in these areas during weekdays, whereas single dog owners have more time to walk their dogs at weekends. Multiple-dog owners may be more likely to have the dogs as a hobby/interest and make particular effort to walk their dogs during weekdays as they enjoy the experience. Multiple dog groups were also more likely to be seen during the morning compared to other times; it may be that the type of owner that chooses to own more than one dog has the time to, or chooses to, walk their dogs twice a day (morning and evening) compared to single dog owners. Interestingly, multiple dog groups tended to consist of more crossbreeds as opposed to pedigree breed types. The type of person who owns more than one dog may prefer cross breed types for some reason.

6.4.3 Number of owners walking the dog

Most dogs were being walked by a single owner. A maximum of six owners were reported to be walking in a dog group; large groups could be due to large family situations (four of the group of 6 were children), but generally only 9% of observations included children. There is evidence that dogs are more likely to be owned by families with children (Chapter Two) and yet children were not commonly seen to be out walking the dog. The duty of walking the dog may be performed by an adult without the presence of the children due to the extra effort required to manage the children and dog at the same time. However, some of the observation periods were during school hours and this may have restricted the availability of children to walk dogs in this study. In contrast to the effect of dog group size, dogs were more likely to be seen with single owners on weekdays compared to at weekends, possibly because the family or friends have more opportunity to walk together at weekends.

The observed differences in number of owners for different dog types may be due to owner preferences when choosing a dog. Pastoral breed types (collies, shepherds) are active dogs with a strong owner bond and it is reasonable to suggest that these may be chosen to be owned by a single owner, or available to be walked by only one person, due to the amount of exercise required. In contrast, a toy dog may be a more likely choice for a larger household with less time to spend walking the dog. There was no significant association found between week or weekend, and type of dog seen, so it is unlikely that these owner differences were just due to the effect of week or weekend.

6.4.4 Type of dog observed

Labradors and cross breeds were the most popular breed types owned and gundogs the most popular Kennel Club group, as also reported in the questionnaire survey (Chapter 3) and for previous UK estimates (Anon 2004b). This suggests that observed dogs may be representative of the area (and, by corollary, that the survey was representative of a wider area than sampled). Of those dogs where sex could be identified there were more males reported than females. This may be due to males being easier to distinctly identify from a distance due to leg cocking and greater visibility of genitalia compared to females. The occurrence of such a bias is supported by the finding of more females than male dogs in a census based study in the local area (Chapter 3).

6.4.5 Defaecation

In approximately two-thirds of observations, all faeces deposited by the dog were picked up by the owner. In two other studies of dog-fouling, 59% and 54% of owners observed were responsible (Webley and Siviter 2000; Wells 2006), slightly less than in this study. In our questionnaire survey over 90% of local dog owners reported always/usually picking up after their dogs (Chapter Three). This observation suggests that people may have been over-reporting this practice in the questionnaire, but it is also possible that sometimes an owner did not realise that their dog had defaecated and if so would have cleared it up. However, the reality is that less faecal material is picked up than owners report. Webley and Siviter (2000) reported 14/36 dog owners claiming that their dog had never fouled, even though unbeknownst to them they had been observed letting their dog foul. This again suggested that self-reporting should not be relied upon. Owners were more likely to pick up faeces when the dog was on lead than off lead and it may be easier to notice in this situation (or conversely harder to ignore). Wells (2006) also observed this phenomenon.

6.4.6 Duration of the observation

The duration of the observation was associated with many other variables, as the longer a dog is observed, the more chance there is of seeing a behaviour performed, and so was controlled for in subsequent analyses. Duration of observation was generally longer at weekends than weekdays, possibly due to the owner being in less of a hurry to walk the dog, or alternatively because the areas were busier and there were more distractions to occupy the dog/owner. The locations having different median durations may have been due to differences in size (although the study areas are roughly similar sized expanses of open space, however not measured precisely) or may have been due to other features of the environment, such as pathways and vegetation. Royden Park has trees and bushes around all sides, Parkgate two sides, and West Kirby none, which may have contributed to less time spent investigating the area. The areas also differed in the location of pathways leading through them and into and out of them, and this would affect the time taken to travel across the study space.

Observation time was significantly increased where there were three or more owners. This may be a consequence of standing chatting or children playing. Toy types were observed for longer periods; it may be that they took longer to traverse the study area due to size. However it is unlikely to be simply due to the effect of size, as Hounds and Working types also took longer and they are not small dogs, and Toy types can move considerably fast if they want to. Longer observation times for these dogs may be due to some behavioural or owner characteristics, but is unlikely to be due to interruptions to perform sniffing behaviour as Gundogs would then be expected to have the longest durations as they comparably spent the most time sniffing.

6.4.7 Lead use

The reason why dogs may have been more commonly seen off lead on weekdays than weekends is unclear. Possible explanations include that the type of owners who are able to (or choose to) walk on weekdays may for some reason like to let their dog off lead, or alternatively, it may be easier to walk multiple dogs off lead than keep them on lead.

Because numbers of interactions with dogs or people were low, it was not possible to investigate factors associated with these interactions in the same manner as for sniffing behaviours, which were much more commonly seen. However, simply comparing the number of interactions when off lead to when on lead suggests that dogs are less likely to interact when on lead. Bradshaw and Lea (1992) observed that the on lead dog was never the initiator of interactions. Putting a dog on lead may serve to reduce the number of interactions it has, and subsequently opportunities for pathogen transmission. However, this study did not assess the lead status of the other dog in an interaction. It may not be a simple process of whether the focal dog is on a lead or not, as some dogs that are off lead may be more likely to approach dogs that are on lead, and in this case both dogs would need to be on lead in order to have an effect on reducing the number of interactions. Duration of interactions with other dogs may also be affected by use of the lead, and appeared to be shorter when the dogs were on lead than when they were off lead. In Bradshaw and Lea (1992) the duration of the interaction was not measured directly but the median numbers of behaviours observed during an interaction was reduced when the recipient dog was on lead.

6.4.8 Percentage duration spent sniffing

On univariable analysis the variables day, time, Kennel Club Group, defaecation and urination were all significantly associated with percentage time spent sniffing. Although location did not appear to affect the percentage of time spent sniffing, it is suggested to have an effect on the mean sniffing episode length. On further multivariable analysis, day, Kennel Club Group and urination appeared to be the most important factors affecting percentage time spent sniffing the ground. The variables lead use, weather, defaecation, and single or multiple owners, were also used in the model building process (as $P<0.3$). Gundog breed types were more likely to perform sniffing behaviours than others, as might be expected by their breeding purpose.

The association between sniffing and urination was not surprising, as dogs can be often seen sniffing around the time of urination, particularly preceding, and especially if the urination is for marking purposes. From an early age all canids will investigate and sniff urine and faeces from other animals, in order to gain information about conspecifics, and may urinate or defaecate on it, or roll in it (Fox 1984). Such close contact during investigation of faeces and urine of other individuals may be an opportunity for pathogen transmission. It has been suggested that female urine deposits are particularly attractive to other dogs (Doty and Dunbar 1974), and therefore the type of dog that previously visited an area may influence the amount of sniffing seen in subsequent dogs. It has also been reported that dogs urine mark more when in unfamiliar places (Pal 2003), and so familiarity of the area to the dog may influence the amount of urine deposited, and subsequently the amount of sniffing behaviour performed by the subject dog and later dogs visiting the area.

Although the variable lead use (on/off/both) was included in building of the multivariable model of sniffing behaviour it was not found to be significant. However, this variable is a simpler estimate of a complex situation. Further investigation of on lead compared to off lead behaviours did show some differences in regards to time spent sniffing. If investigating those dogs who were observed both on and off lead (20%) they were seen to spend significantly more time sniffing when off lead than when on lead. Therefore, putting a dog on lead may also reduce sniffing behaviours (in addition to interactions with dogs or people). However, if dogs that were only observed on lead were compared to those only observed off lead, a difference approaching significance was seen. An explanation of these findings is that if dogs are not allowed off lead, they are forced to perform the sniffing behaviours whilst on lead, but if given opportunity would prefer to preserve sniffing behaviour until they are off lead.

6.4.8 Conclusion

This study provides new understanding of the general frequencies of interactions that pet dogs can have with the environment, other dogs, and people, whilst walking. The most considerable limitation of this study is that it did not record the number of other dogs and people that a subject had opportunity to interact with, and this would obviously effect the likelihood of observing an interaction. Although recording such information was considered, it was deemed difficult to categorise the distance at which a dog may be deemed able to interact with another dog/person, and this is also likely to vary depending on the dog and environment and would be difficult to standardise across all dogs. In addition, the practicalities of recording more data were not feasible and would have compromised data quality. Another major limitation is that the study was only conducted in three areas, and these were all in the Wirral / Cheshire area, and many behaviours of the type observed are likely to be affected by the walking environment.

The findings that interacting with people and interacting with dogs were significantly associated suggests that the two are closely linked, as might be expected; dogs tend to have owners and people tend to be walking a dog when in these areas. However, interactions with people were rarely observed compared to interactions with dogs. Use of the lead may influence the frequency of interactions but this requires further investigation.

APPENDIX TO CHAPTER SIX

Table 1. Univariable regression analysis of log percentage time spent sniffing – Independent variables.

Variable	Coef	SE Coef	P-value
Week or weekend?			0.23
Constant (week day)	1.07	0.04	
Weekend day	0.08	0.06	0.23
Day			**0.05**
Constant (Friday)	0.92	0.08	
Saturday 1	0.18	0.11	0.10
Sunday	0.31	0.11	<0.01
Tuesday	0.29	0.10	0.01
Thursday	0.13	0.11	0.24
Saturday 2	0.17	0.11	0.12
Time			**0.05**
Constant (8-9.59am)	1.19	0.07	
10-11.59am	0.04	0.11	0.97
1-2.59pm	-0.10	0.10	0.33
3-4.59pm	-0.11	0.10	0.26
5-7.30pm	-0.24	0.10	0.12
Location			0.73
Constant (Parkgate)	1.12	0.06	
West Kirby	-0.06	0.08	0.46
Royden Park	-0.01	0.08	0.87
Weather			0.06
Constant (Rain)	1.37	0.13	
Sun	-0.30	0.13	0.02
Cloudy	-0.23	0.12	0.11
Number of dogs in unit			0.57
Constant (single)	1.11	0.04	
Two	-0.06	0.07	0.39
Three or more	0.06	0.12	0.63
Single or multiple dogs in unit			0.60
Constant (single)	1.15	0.09	
Multiple	-0.04	0.07	0.60
Number of owners in unit			0.40
Constant (single)	1.06	0.04	
Two	0.08	0.07	0.25
Three or more	0.10	0.10	0.35
Single or multiple owners in unit			0.18
Constant (single)	0.98	0.09	
Multiple	0.09	0.06	0.18
UK Kennel Club Group			**0.001**
Constant (Gundog)	1.27	0.05	
Crossbreed	-0.22	0.10	0.03
Hound and Working	-0.22	0.15	0.14
Pastoral	-0.41	0.09	<0.001
Terrier	-0.17	0.09	0.07
Toy	-0.12	0.14	0.40
Utility	-0.18	0.14	0.21
Breed?			0.55
Constant (Mixed breed)	1.06	0.09	
Recognised breed	0.06	0.09	0.55
Lead use			0.27
Constant (Both on and off lead)	1.09	0.07	
On Lead only	-0.11	0.10	0.30
Off lead only	0.03	0.08	0.66

Table 2. Univariable regression analysis of log percentage time spent sniffing – Other behaviours.

Variable	Coef	SE Coef	P-value
Defaecation observed			**0.01**
Constant (No)	1.07	0.03	
Yes	0.27	0.10	0.01
Urination observed			**<0.001**
Constant (No)	0.98	0.04	
Yes	0.34	0.06	<0.001
Interacted with other dog during observation			0.46
Constant (No)	1.12	0.04	
Yes	-0.05	0.07	0.46
Rate of interacting with different dogs			0.73
Constant	1.11	0.03	
Rate of interacting with different dogs	-0.04	0.12	0.73
Rate of all interactions with other dogs			0.50
Constant	1.11	0.03	
Rate of all interactions with other dogs	-0.04	0.07	0.50
Percentage duration of interacting with other dogs			0.38
Constant	1.11	0.03	
Percentage duration of interacting with other dogs	-0.45	0.52	0.38
Percentage duration of interacting with other dogs (excluding observations with no other dogs)			0.55
Constant	1.09	0.07	
Percentage duration of interacting with other dogs	-0.35	0.59	0.55
Interacted with a person during observation			0.92
Constant (No)	1.10	0.03	
Yes	0.01	0.11	0.92
Rate of interacting with different people			0.95
Constant	1.10	0.03	
Rate of interacting with different people	-0.01	0.21	0.95
Rate of all interactions with people			0.93
Constant	1.10	0.03	
Rate of all interactions with people	0.01	0.11	0.93

CHAPTER SEVEN

THE EFFECT OF LEAD USE ON DOG INTERACTIONS WITH OTHER DOGS AND PEOPLE

ABSTRACT

Pet dogs have opportunity to interact with other dogs and people when they are walked. During these interactions it is possible that a disease may be transmitted from one dog to another, or from a dog to a person (or vice versa). Aggressive encounters may also occur. Whether a dog is on lead or not whilst on a walk could affect the frequency in which it interacts with other dogs and people that it meets.

This experimental study observed ten dogs using a video camera, and recorded the number of possible and actual interactions with people and dogs that occurred whilst the dogs were walked along a pre-defined route. The lead status of the subject dog, the lead status of the other dog, and the direction that the dogs were travelling, were all used to model the outcome of whether an interaction with a dog occurred. Analysis was performed using a hierarchical multilevel model, accounting for dog and session.

The results suggest that lead status of both dogs was important in influencing whether or not an interaction occurred and there were no statistical interactions between variables. Therefore, putting a dog on lead is influential in reducing the number of dog-dog interactions that occur, and for best effect in reducing disease spread (or damage in aggressive encounters), both dogs should be on a lead.

7.1 INTRODUCTION

Interactions between pet dogs allow for potential disease transmission, for example via aerosol or saliva spread. Whether a dog is on lead or not whilst on a walk could affect the frequency in which it interacts with other dogs and people that it meets. Thus, this possible intervention could be used to reduce disease transmission between dogs, or even between dogs and people, in a situation of disease outbreak. It may also be useful in reducing agnostic encounters between dogs.

Bradshaw and Lea (1992) studied the behavioural sequences during interactions between two dogs and reported that no dog on lead was ever the initiator of an interaction, and did not observe any interactions where both dogs were on lead. It is reasonable to hypothesise that when presented with opportunities for interaction with other dogs, the likelihood of an interaction occurring may be lower if the dog is on lead than if off lead, but this has not been scientifically studied before. It is also possible that the on/off lead status of the other dog may also affect the probability and/or nature of the interaction. The effect of putting a dog on lead may also vary depending on whether the other dogs in the environment are on or off lead.

This study was designed to test the effect of lead use on the probability of an interaction with another dog. Due to the lower numbers of interactions with people compared to dogs expected, as observed previously (Chapter 6), statistical analysis on the effect of lead use on interactions with people was not possible, and only a general description of these interactions is therefore reported.

7.2 METHODS

7.2.1 Recruitment and videoing

Ten dogs (Table 7.1) (subjects) were recruited into the study, as this was deemed an achievable number of dogs to observe in the time available. The dog owners were recruited via posters/email at the University Veterinary Teaching Hospital for convenience. The study area chosen was a stretch of old railway line (now a country park), that takes 10-15mins to walk between the chosen start and end points. The dogs were all familiar with the area and had walked the route at least once previously. The volunteer dogs recruited were all over 1yr of age, of various breeds, and the owner stated that they were comfortable walking the dog both on and off lead around other dogs. Data was collected between November 2006 and April 2007 between the hours of 8.30am and 5pm on both week and weekend days. Each dog was required to walk the route (in both directions) on two occasions, no more than 2 weeks apart, and at the same time and day of the week. In the first session the dog walked the length of the route off lead first and then on lead on the way back. In the second session the on and off lead walking was reversed, to account for any behaviour differences due to stage during walk (e.g. beginning/end) rather than lead use.

Owners were instructed to behave normally with the dog, other than keeping them on/off lead as requested, and did not know the purpose of the study other than to 'observe dog behaviour whilst walking'. At the beginning of each session the dog was provided with two minutes off lead in a nearby park, and was then walked on lead to the start of the study area (approx another 2 minutes), in order to acclimatise to the observer following them. All observations were carried out by a single observer and recorded using a concealed video camera (Canon M500i) with a sports camera attachment (Bullet/helmet colour camera, Model Land and Air) (Cameras4sports 2007) which was hidden in the observer's hand and pointed towards the focal dog.

Table 7.1 Subject dogs recruited for the trial.

Dog	Breed	Age	Sex/neutered	Type of owner	Household dogs	Other comment
A	Labrador	6	MN	F	1	
B	Jack Russell Terrier X	13	FN	M	1	
C	Chihuahua X Jack Russell Terrier	1	MN	M	1	
D	Rough Collie	3	FN	M	1	
E	Labrador X Collie	6	F	F	1	
F	Yorkshire Terrier	8	F	F	3	Lives with I
G	Staffordshire Bull Terrier X Whippet?	5	MN	F	2	Lives with H
H	Yorkshire Terrier X Daschund	4	FN	F	2	Lives with G
I	Yorkshire Terrier	8	F	F	3	Lives with F
J	Collie	6	FN	F	1	

7.2.2 Data collection

On each walk, the dog had opportunities to interact both with walkers travelling in the same general direction as the dog, and also in the opposite direction. It was recorded how many walkers the dog could, and did, interact with, and the proportion of possible interactions that occurred was calculated. The same process was conducted for cyclists, horse riders and other dogs met (and whether the other dog was on or off lead). An interaction was considered possible if the person/dog was seen at any point on the video recording for that walk. The wide angled lens captured the entire width of the path and a considerable distance ahead could be seen, subject to turnings of the path. Due to the enclosed nature of the pathway, potential interactors are forced to pass fairly close and would be seen on the film. An interaction with a person was defined as physical (e.g. jumping up, nudging with nose or petting) and with a dog being close enough to sniff/play (see Chapter 6, section 6.2.3).

7.2.3 Data analysis

Data were stored in an Excel spreadsheet (Microsoft 2003) and descriptive analysis was conducted in Minitab (Minitab.Inc 2005). Multivariable three-level models were developed initially using a residual iterative generalised least-squares (RIGLS) algorithm and second order penalised quasi-likelihood (PQL) in MLwiN (CMM 2006), with the variables dog, session and "potential interaction" as levels 3, 2 and 1, respectively, to account for variability between dogs and between days for each dog (session 1 or 2) (Fig.7.1). The outcome of the model was binary; whether or not an actual interaction occurred when there was potential for an interaction with another dog. The variables considered for inclusion in the model were: whether the subject dog was on or off lead, whether the other dog was on or off lead, and whether the two dogs were being walked in the same direction or opposite (i.e. from which direction the owners were travelling). Two- and three-way interactions between these variables were also tested for. Variables which were not significant in the multilevel model were removed sequentially by backward elimination of non-significant variables (Wald χ^2 $P<0.05$).

The final model was fitted by Markov-chain Monte Carlo (MCMC) simulation using a Metropolis-Hastings sampler with diffuse priors (Rasbach and others 2000). The number of iterations used was determined by examination of the Raftery-Lewis and Brooks-Draper Nhat statistics (Rasbach and others 2000). This indicated that a chain of 50,000 iterations was sufficient. The fit of each model was assessed by examining the posterior distributions of the fixed variables included in the model (data not shown). Following the selected burn-in period and chain length, all fits were smooth and regular and approximated a normal distribution. The model building process was also repeated (data not shown) with an additional level of owner (as there were two pairs of dogs walked by the same owner) (Fig 7.1).

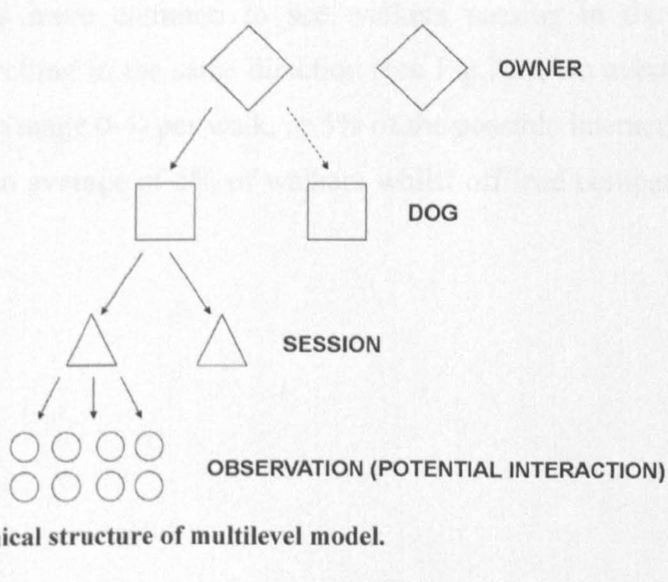


Figure 7.1 Hierarchical structure of multilevel model.

7.3 RESULTS

7.3.1 Duration

The mean walk duration was 731 seconds (median 719 seconds). On lead walks lasted 597-868 seconds (mean 698, median 597 seconds) and off lead walks generally took longer, ranging 628-978 seconds (mean 765, median 628 seconds). Durations for each dog are displayed in Table 7.2; all dogs except one took longer to walk the route off lead than on lead. Whether walk times were longer during session one or session two was variable.

Table 7.2 Walk durations for each dog.

Dog	Mean walk duration (range) (s)	Mean walk duration off lead (s)	Mean walk duration on lead (s)	Mean walk duration session 1 (s)	Mean walk duration session 2 (s)
A	696 (654-771)	724	669	665	727
B	875 (810-978)	917	834	918	832
C	719 (597-964)	808	630	625	813
D	650 (618-680)	671	628	649	650
E	627 (614-642)	635	618	632	621
F	786 (726-876)	845	727	801	771
G	667 (626-759)	707	628	640	694
H	678 (629-729)	721	635	677	679
I	782 (757-840)	799	765	807	757
J	836 (777-877)	827	844	849	823

7.3.2 Walkers

Results for interactions with walkers are presented in the Appendix for this Chapter, Table 1.

Dogs had opportunity to interact with 0-24 walkers on a walk (mean 9.0). As might be expected, it was more common to see walkers passing in the opposite direction compared to travelling in the same direction (see Fig.7.2). On average a dog interacted with 0.5 walkers (range 0-4) per walk, or 5% of the possible interactions (Fig.7.3). Dogs interacted with an average of 5% of walkers whilst off lead compared to 4% whilst on lead (Fig 7.4).

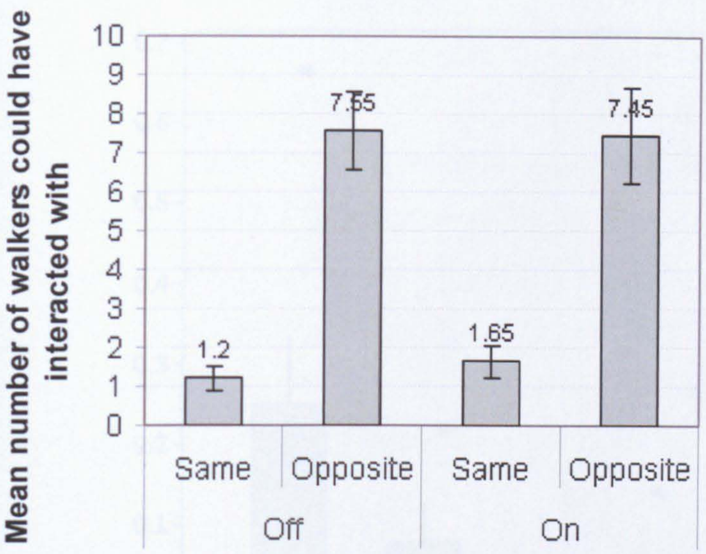


Figure 7.2 Mean number (and standard error) of walkers that the subject dogs could have interacted with on their walk.

Figure 7.3 An interaction between a person and a dog.

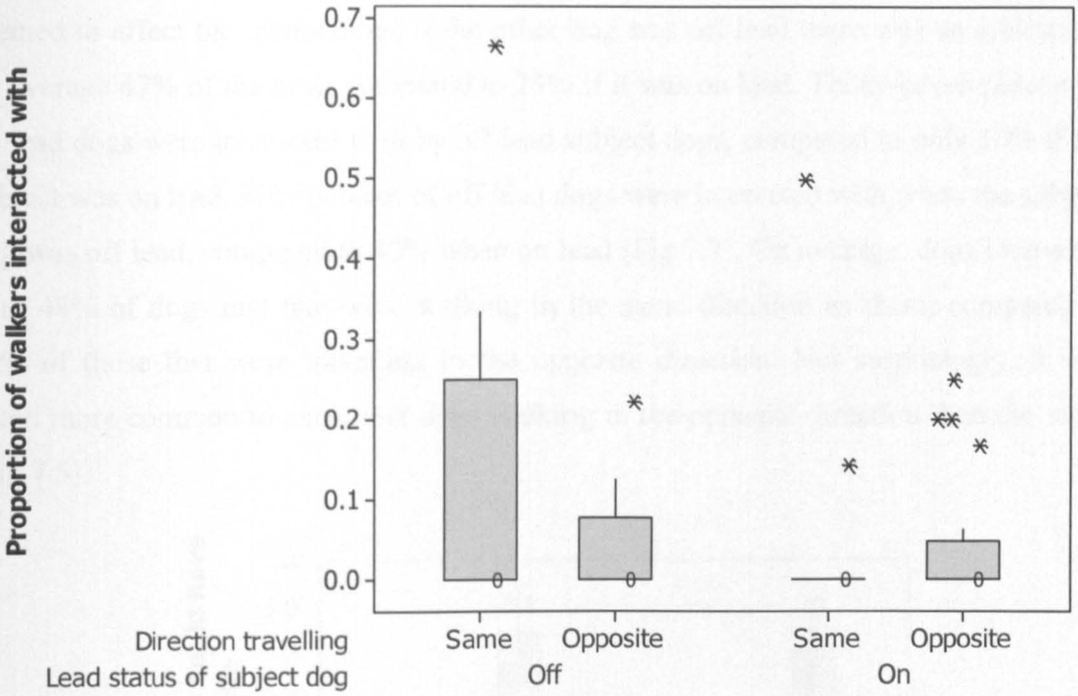


Figure 7.4 Boxplot of proportion of walkers that the subject dogs interacted with on their walk (medians labelled).

7.3.3 Cyclists

On 26 walks the dog had the opportunity to interact with at least one cyclist (range 0-9 seen). On average, dogs had the opportunity to interact with 1.9 cyclists per walk. No interaction with a cyclist was ever observed.

7.3.4 Horses

No dogs were observed to interact with a horse or rider. Only 2 dogs were walked when there was a horse.

7.3.5 Dogs

Full results for interactions with other dogs (on or off lead) are presented in the Appendix for Chapter 7, Table 2. Subject dogs had opportunities to interact with 0-13 dogs on a walk (mean 5, 1.3 that were on a lead and 3.75 that were off lead, Fig.7.5). On average a subject interacted with 1.9 dogs (range 0-10) per walk (Fig.7.6), which was an average of 38% of all dogs and this ranged from 0-100% between the dogs. When off lead, subject dogs interacted with a mean of 44% compared to 32% of dogs when the subject dog was on lead. Whether the dog being met was on or off lead also seemed to affect the interactions; if the other dog was off lead there was an interaction on average 47% of the time, compared to 23% if it was on lead. Thirty-seven percent of on lead dogs were interacted with by off lead subject dogs, compared to only 10% if the subject was on lead. Fifty percent of off lead dogs were interacted with when the subject dog was off lead, compared to 45% when on lead (Fig.7.7). On average, dogs interacted with 48% of dogs met that were walking in the same direction as them, compared to 27% of those that were travelling in the opposite direction. Not surprisingly, it was much more common to encounter dogs walking in the opposite direction than the same (Fig.7.5).

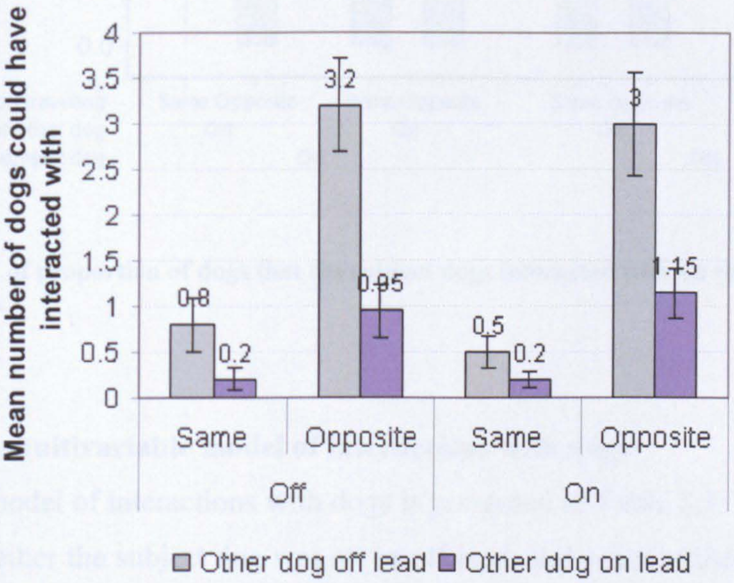


Figure 7.5 Mean number (and standard error) of other dogs that the subject dogs could have interacted with on their walk.

a)

b)

Figure 7.6 Interactions between dogs, a) subject on lead and b) subject off lead.

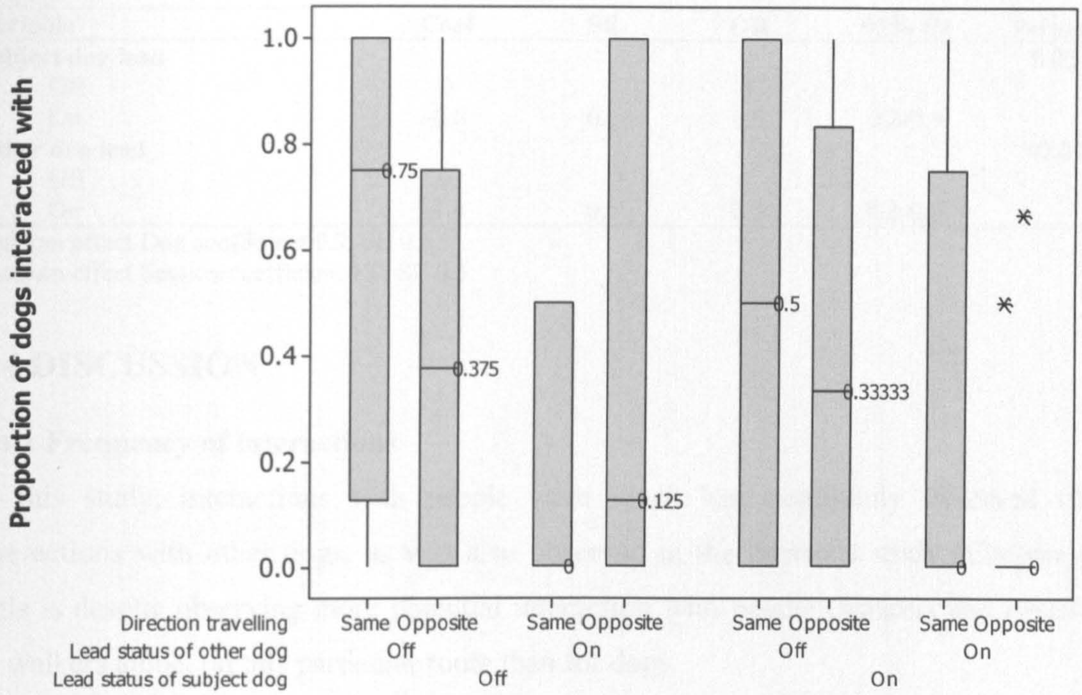


Figure 7.7 Boxplot of proportion of dogs that the subject dogs interacted with on their walk (medians labelled).

7.3.6 Multilevel multivariable model of interactions with dogs

The multilevel model of interactions with dogs is presented in Table 7.3. The significant factors were whether the subject dog was on or off lead, and whether the other dog was on or off lead. There was less likelihood of an interaction occurring if the subject dog was on lead compared to if off lead (OR=0.5), or conversely, a dog was twice as likely to interact with another dog when off lead compared to if on lead (OR=2.2). If the other dog was on lead an interaction was again less likely than if off lead (OR=0.3), or in other words, an interaction was almost four times more likely to happen with an off lead dog than an on lead dog (OR=4.0). Statistical interaction terms were tested in the model and none were significant. The model building process was also tested with an additional hierarchy level of owner (as there were two pairs of dogs walked by the same owner) but this made only a minute difference to the results.

Table 7.3 Multilevel multivariable model of interactions with other dogs (MCMC, dog and session levels).

Variable	Coef	SE	OR	95% CI	P-value
Subject dog lead					0.02
Off	0		1		
On	-0.8	0.3	0.5	0.2-0.9	
Other dog lead					<0.01
Off	0		1		
On	-1.4	0.5	0.3	0.1-0.6	

Random effect Dog coefficient 0.2, SE 0.6.
Random effect Session coefficient 1.0, SE 0.5.

7.4 DISCUSSION

7.4.1 Frequency of interactions

In this study, interactions with people were much less commonly observed than interactions with other dogs, as was also observed in the previous study (Chapter 6). This is despite observing more potential interaction with people (walkers and cyclists) or walkers alone, on this particular route than for dogs.

7.4.2 Effect of lead use

The findings of this study suggest that it is of consequence whether either of the dogs in an interaction is on lead or off lead. In order to prevent interactions occurring, putting either dog on lead will reduce the number of interactions, but for greatest effect both dogs should be on lead. Therefore in face of a disease outbreak, it would be important that everyone followed a lead-rule, if interactions were to be significantly reduced. There was no evidence for any interaction effects between the variables, therefore the effect of the lead use for one dog did not vary depending on the lead state of the other dog.

7.4.3 Possible biases

In this study, the lead state of the other dog was suggested to have more influence than the lead state of the subject dog (OR 4.0 compared to 2.2, as the inverse of those presented in Table 7.3). It may be that our subject dogs were under better control than the general public dogs met, although our owners were instructed to act as normal and allow the dog to do as it wishes, within reason. However, all of our owners were happy for their dogs to be off lead around other dogs, in order for them to participate in our study in the first instance, and this may have biased our selection of owners toward those with well controlled dogs. Again as in Chapter 6, it is possible that the presence of the observer had an effect on the subjects, and in this study this may have been even more of an issue, as the observer was actually walking with the dog and owner. Habituation of the dog to being followed by the observer before each session hopefully minimised this. It was also not possible to blind the observer, or the owner (who knew they were being filmed), as to whether the dog was on or off lead, and this may have affected their behaviour. However, the owner was not made aware that the study was to assess differences in interactions with people and dogs between on and off lead.

This study used only a very small number of subjects and one walking route. The chosen subjects and the environment are likely to have had a large effect on the type of behaviour seen, in particular the use of a relatively narrow walking path rather than a field / park. In a larger open space, where the dogs are not forced to pass so close together, it could be hypothesised that there may be an even bigger reduction in contact due to use of the lead. Many of the subjects were small terrier types and these may behave differently to other types of dogs, and so care should be taken when generalising the findings to other dogs in general.

7.4.4 Comparison to previous studies

In the observations by Bradshaw and Lea (1992) no interactions were observed between two on lead dogs, whereas these interactions were seen in our study. Our study site was an old railway line, which is likely to have been narrow compared to the common and forest used in the previous study, and so dogs may have been forced closer together, allowing interactions between two on lead dogs. In addition, we included extendible flexi-leads in our on lead analysis (two owners), as the owner has considerable control over the animal and they can be locked short. Extendible leads may have allowed the other dog more freedom to interact with our subject dog than if on a short lead. It is unnoted whether extendible leads were included in the Bradshaw and Lea study, but they were much less commonly used at the time of this data collection (late 1980s).

In the study by Bradshaw and Lea (1992) it was noted that the probability of growling increased when one dog was on the lead. No obvious aggression was seen in our study, but we had initially selected dogs that were able to be walked around other dogs. Bekoff and Meaney (1997) stated that their observers all noted that off lead dogs were friendlier than dogs on lead, although no detailed data were collected on this aspect of behaviour.

In a small postscript note in the paper by Bekoff and Meaney (1997) findings from an otherwise unpublished study are reported; on lead dogs were seen to initiate contact with humans 5.5 times more than off lead dogs, and people initiated contact with on lead dogs 3.8 times more than with off lead dogs. This is in contrast to our findings (although our differences were only small), but there is no published detail on the methodology and analysis of their study in order to assess its validity or compare to our study. However, off lead dogs in their study generally ignored humans and interacted with their surroundings and other off lead dogs instead, similar to our findings.

7.4.5 Variability between dogs and between sessions

Although the amount of variation at the dog level was estimated in the multivariable model, it is inappropriate to interpret this as variation between dogs, as it also includes variation due to the differing times of day/days of week/months at which dogs were observed. However, it does suggest that there was more variation between the sessions than there was between the dogs; this is likely due to different opportunities for interactions between the sessions.

7.4.6 Conclusions

The results suggest that lead status of both dogs in a potential interaction is important in influencing whether or not the interaction will occur. Therefore, putting a dog on lead might be a recommended method to reduce the number of dog-dog interactions, and for best effect to reduce disease spread, both dogs should be on a lead. Further studies with more subjects are required to assess the behavioural nature of on lead and off lead interactions, and whether there are breed/age/size, or environmental, differences that may affect the way dogs behave.

APPENDIX TO CHAPTER SEVEN

Table 1. Interactions with walkers – mean number of possible interactions opportunities, interactions that did happen, and proportion of possible interactions that did occur.

Dog	Lead	Direction	Could have interacted with (mean)	Did interact with (mean)	Proportion
All	Any	Any	8.93	0.45	0.05
		Same	1.53	0.15	0.07
		Opposite	7.50	0.30	0.04
	Off	Any	8.75	0.50	0.05
		Same	1.20	0.20	0.11
		Opposite	7.55	0.30	0.03
	On	Any	9.10	0.40	0.04
		Same	1.65	0.10	0.04
		Opposite	7.45	0.30	0.04
A	Any	Any	13.00	1.25	0.08
		Same	3.50	0.50	0.13
		Opposite	9.50	0.75	0.07
	Off	Any	13.50	1.00	0.08
		Same	3.50	0.50	0.13
		Opposite	10.00	0.50	0.04
	On	Any	12.50	1.50	0.09
		Same	3.50	0.50	0.14
		Opposite	9.00	1.00	0.10
B	Any	Any	7.50	0.25	0.02
		Same	1.50	0.00	0.00
		Opposite	6.00	0.25	0.02
	Off	Any	10.00	0.50	0.04
		Same	1.00	0.00	0.00
		Opposite	9.00	0.50	0.04
	On	Any	5.00	0.00	0.00
		Same	2.00	0.00	0.00
		Opposite	3.00	0.00	0.00
C	Any	Any	8.00	1.25	0.13
		Same	2.25	0.50	0.22
		Opposite	5.75	0.75	0.12
	Off	Any	9.50	2.00	0.17
		Same	1.50	1.00	0.67
		Opposite	8.00	1.00	0.11
	On	Any	6.50	0.50	0.10
		Same	3.00	0.00	0.00
		Opposite	3.50	0.50	0.13
D	Any	Any	7.50	0.25	0.03
		Same	1.75	0.00	0.00
		Opposite	5.75	0.25	0.03
	Off	Any	8.00	0.50	0.06
		Same	2.00	0.00	0.00
		Opposite	6.00	0.50	0.06
	On	Any	7.00	0.00	0.00
		Same	1.50	0.00	0.00
		Opposite	5.50	0.00	0.00
E	Any	Any	12.25	0.75	0.06
		Same	2.00	0.25	0.11
		Opposite	10.25	0.50	0.04
	Off	Any	10.50	0.00	0.10
		Same	1.50	0.50	0.33
		Opposite	9.00	0.50	0.04
	On	Any	14.00	0.50	0.03
		Same	2.50	0.00	0.00
		Opposite	11.50	0.50	0.03

Table 1 (continued). Interactions with walkers – mean number of possible interactions opportunities, interactions that did happen, and proportion of possible interactions that did occur.

Dog	Lead	Direction	Could have interacted with (mean)	Did interact with (mean)	Proportion
F	Any	Any	7.75	0.50	0.07
		Same	1.00	0.25	0.17
		Opposite	6.75	0.25	0.05
	Off	Any	7.50	0.00	0.00
		Same	0.50	0.00	0.00
		Opposite	7.00	0.00	0.00
	On	Any	8.00	1.00	0.14
		Same	1.50	0.50	0.25
		Opposite	6.50	0.50	0.10
G	Any	Any	3.75	0.00	0.00
		Same	0.50	0.00	0.00
		Opposite	3.25	0.00	0.00
	Off	Any	1.50	0.00	0.00
		Same	0.00	0.00	*
		Opposite	1.50	0.00	0.00
	On	Any	6.00	0.00	0.00
		Same	1.00	0.00	0.00
		Opposite	5.00	0.00	0.00
H	Any	Any	16.25	0.00	0.00
		Same	0.75	0.00	0.00
		Opposite	15.5	0.00	0.00
	Off	Any	14.00	0.00	0.00
		Same	1.00	0.00	0.00
		Opposite	13.00	0.00	0.00
	On	Any	18.50	0.00	0.00
		Same	0.50	0.00	0.00
		Opposite	18.00	0.00	0.00
I	Any	Any	8.50	0.00	0.00
		Same	0.75	0.00	0.00
		Opposite	7.75	0.00	0.00
	Off	Any	9.00	0.00	0.00
		Same	0.50	0.00	0.00
		Opposite	8.50	0.00	0.00
	On	Any	8.00	0.00	0.00
		Same	1.00	0.00	0.00
		Opposite	7.00	0.00	0.00
J	Any	Any	4.75	0.25	0.04
		Same	0.25	0.00	0.00
		Opposite	4.50	0.25	0.04
	Off	Any	4.00	0.00	0.00
		Same	0.50	0.00	0.00
		Opposite	3.50	0.00	0.00
	On	Any	5.50	0.50	0.08
		Same	0.00	0.00	*
		Opposite	5.50	0.50	0.08

Table 2. Interactions with other dogs – mean number of possible interactions opportunities, interactions that did happen, and proportion of possible interactions that did occur.

Dog	Lead	Direction	Could have interacted with (mean) (other dog on lead, other dog off lead)	Did interact with (mean) (other dog on lead, other dog off lead)	Proportion (other dog on lead, other dog off lead)
All	Any	Any	5.00 (1.25, 3.75)	1.95 (0.25, 1.68)	0.38 (0.23, 0.47)
		Same	0.85 (0.20, 0.65)	0.48 (0.05, 0.43)	0.48 (0.21, 0.60)
		Opposite	4.15 (1.05, 3.10)	1.45 (0.20, 1.25)	0.37 (0.26, 0.43)
	Off	Any	5.15 (1.15, 4.00)	2.45 (0.30, 2.15)	0.44 (0.39, 0.50)
		Same	1.00 (0.20, 0.80)	0.60 (0.05, 0.55)	0.48 (0.17, 0.63)
		Opposite	4.15 (0.95, 3.20)	1.85 (0.25, 1.60)	0.40 (0.43, 0.43)
	On	Any	4.85 (1.35, 3.50)	1.40 (0.20, 1.20)	0.32 (0.10, 0.45)
		Same	0.70 (0.20, 0.50)	0.35 (0.05, 0.30)	0.48 (0.25, 0.57)
		Opposite	4.15 (1.15, 3.00)	1.05 (0.15, 0.90)	0.34 (0.11, (0.43)
A	Any	Any	4.25(0.75, 3.50)	2.00 (0.25, 1.75)	0.43 (0.50, 0.45)
		Same	0.75 (0.00, 0.75)	0.50 (0.00, 0.50)	0.67 (*, 0.67)
		Opposite	3.50 (0.75, 2.75)	1.50 (0.25, 1.25)	0.44 (0.50, 0.44)
	Off	Any	4.00 (0.50, 3.50)	2.50 (0.50, 2.00)	0.57 (1.00, 0.40)
		Same	1.00 (0.00, 1.00)	0.50 (0.00, 0.50)	0.50 (*, 0.50)
		Opposite	3.00 (0.50, 2.50)	2.00 (0.50, 1.50)	0.63 (1.00, 0.38)
	On	Any	4.50 (1.00, 3.50)	1.50 (0.00, 1.50)	0.30 (0.00, 0.50)
		Same	0.50 (0.00, 0.50)	0.50 (0.00, 0.50)	1.00 (*, 1.0)
		Opposite	4.00 (1.00, 3.00)	1.00 (0.00, 1.00)	0.25 (0.00, 0.50)
B	Any	Any	4.50 (2.00, 2.50)	2.50 (0.75, 1.75)	0.46 (0.39, 0.60)
		Same	1.50 (0.50, 1.00)	1.25 (0.25, 1.00)	0.88 (0.50, 1.00)
		Opposite	3.00 (1.50, 1.50)	1.25 (0.50, 0.75)	0.27 (0.33, 0.25)
	Off	Any	6.00 (2.50, 3.50)	3.00 (0.50, 2.50)	0.51 (0.25, 0.71)
		Same	2.00 (1.00, 1.00)	1.50 (0.50, 1.00)	0.75 (0.50, 1.00)
		Opposite	4.00 (1.50, 2.50)	1.50 (0.00, 1.50)	0.21 (0.00, 0.38)
	On	Any	3.00 (1.50, 1.50)	2.00 (1.00, 1.00)	0.40 (0.67, 0.50)
		Same	1.00 (0.00, 1.00)	1.00 (0.00, 1.00)	1.00 (*, 1.00)
		Opposite	2.00 (1.50, 0.50)	1.00 (1.00, 0.00)	0.33 (0.76, 0.00)
C	Any	Any	5.75 (0.75, 5.00)	4.50 (0.25, 4.25)	0.73 (0.33, 0.81)
		Same	2.00 (0.50, 1.50)	1.25 (0.00, 1.25)	0.44 (0.00, 0.75)
		Opposite	3.75 (0.25, 3.50)	3.25 (0.25, 3.00)	0.88 (1.00, 0.88)
	Off	Any	7.50 (0.50, 7.00)	7.00 (0.50, 6.50)	0.95 (1.00, 0.95)
		Same	2.00 (0.00, 2.00)	2.00 (0.00, 2.00)	1.00 (*, 1.00)
		Opposite	5.50 (0.50, 5.00)	5.00 (0.50, 4.50)	0.93 (1.00, 0.93)
	On	Any	4.00 (1.00, 3.00)	2.00 (0.00, 2.00)	0.50 (0.00, 0.67)
		Same	2.00 (1.00, 1.00)	0.50 (0.00, 0.50)	0.17 (0.00, 0.50)
		Opposite	2.00 (0.00, 2.00)	1.50 (0.00, 1.50)	0.83 (*, 0.83)
D	Any	Any	7.25 (0.50, 6.75)	2.75 (0.25, 2.50)	0.37 (0.50, 0.38)
		Same	1.75 (0.25, 1.50)	0.75 (0.00, 0.75)	0.33 (0.00, 0.50)
		Opposite	5.50 (0.25, 5.25)	2.00 (0.25, 1.75)	0.38 (1.00, 0.36)
	Off	Any	7.50 (0.50, 7.00)	3.50 (0.50, 3.00)	0.47 (1.00, 0.44)
		Same	2.00 (0.00, 2.00)	1.00 (0.00, 1.00)	0.50 (*, 0.50)
		Opposite	5.50 (0.50, 5.00)	2.50 (0.50, 2.00)	0.47 (1.00, 0.44)
	On	Any	7.00 (0.50, 6.50)	2.00 (0.00, 2.00)	0.28 (0.00, 0.32)
		Same	1.50 (0.50, 1.00)	0.50 (0.00, 0.50)	0.25 (0.00, 0.50)
		Opposite	5.50 (0.00, 5.50)	1.50 (0.00, 1.50)	0.29 (*, 0.29)
E	Any	Any	4.75 (0.75, 4.00)	1.50 (0.00, 1.50)	0.44 (0.00, 0.52)
		Same	0.50 (0.00, 0.50)	0.25 (0.00, 0.25)	0.50 (*, 0.50)
		Opposite	4.25 (0.75, 3.50)	1.25 (0.00, 1.25)	0.36 (0.00, 0.44)
	Off	Any	5.00 (1.50, 3.50)	2.00 (0.00, 2.00)	0.38 (0.00, 0.54)
		Same	1.00 (0.00, 1.00)	0.50 (0.00, 0.50)	0.50 (*, 0.50)
		Opposite	4.00 (1.50, 2.50)	1.50 (0.00, 1.50)	0.21 (0.00, 0.38)
	On	Any	4.50 (0.00, 4.50)	1.00 (0.00, 1.00)	0.50 (*, 0.50)
		Same	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	* (*, *)
		Opposite	4.50 (0.00, 4.50)	1.00 (0.00, 1.00)	0.50 (*, 0.50)

Table 2 (continued). Interactions with other dogs – mean number of possible interactions opportunities, interactions that did happen, and proportion of possible interactions that did occur.

Dog	Lead	Direction	Could have interacted with (mean) (other dog on lead, other dog off lead)	Did interact with (mean) (other dog on lead, other dog off lead)	Proportion (other dog on lead, other dog off lead)
F	Any	Any	6.50 (3.00, 3.50)	1.00 (0.50, 0.50)	0.21 (0.13, 0.42)
		Same	0.50 (0.25, 0.25)	0.25 (0.25, 0.00)	0.50 (1.00, 0.00)
		Opposite	6.00 (2.75, 3.25)	0.75 (0.25, 0.50)	0.19 (0.06, 0.42)
	Off	Any	5.50 (3.50, 2.00)	1.00 (0.50, 0.50)	0.13 (0.13, 0.25)
		Same	0.00 (0.00, 1.00)	0.00 (0.00, 0.00)	* (*, *)
		Opposite	5.50 (3.50, 2.00)	1.00 (0.50, 0.50)	0.13 (0.13, 0.25)
	On	Any	7.50 (2.50, 5.00)	1.00 (0.50, 0.50)	0.29 (0.13, 0.50)
		Same	1.00 (0.50, 0.50)	0.50 (0.50, 0.00)	0.50 (1.00, 0.00)
		Opposite	6.50 (2.00, 4.50)	0.50 (0.00, 0.50)	0.25 (0.00, 0.50)
G	Any	Any	2.25 (0.75, 1.50)	0.75 (0.00, 0.75)	0.24 (0.00, 0.50)
		Same	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	* (*, *)
		Opposite	2.25 (0.75, 1.50)	0.75 (0.00, 0.75)	0.24 (0.00, 0.50)
	Off	Any	1.50 (0.00, 1.50)	0.50 (0.00, 0.50)	0.33 (*, 0.33)
		Same	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	* (*, *)
		Opposite	1.50 (0.00, 1.50)	0.50 (0.00, 0.50)	0.33 (*, 0.33)
	On	Any	3.00 (1.50, 1.50)	1.00 (0.00, 1.00)	0.20 (0.00, 0.67)
		Same	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	* (*, *)
		Opposite	3.00 (1.50, 1.50)	1.00 (0.00, 1.00)	0.20 (0.00, 0.67)
H	Any	Any	5.25 (2.00, 3.25)	0.50 (0.00, 0.50)	0.09 (0.00, 0.13)
		Same	0.75 (0.25, 0.50)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
		Opposite	4.50 (1.75, 2.75)	0.50 (0.00, 0.50)	0.10 (0.00, 0.15)
	Off	Any	5.50 (1.50, 4.00)	0.50 (0.00, 0.50)	0.08 (0.00, 0.10)
		Same	0.50 (0.50, 0.50)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
		Opposite	4.50 (1.00, 3.50)	(0.50 0.00, 0.50)	0.10 (0.00, 0.13)
	On	Any	5.00 (2.50, 2.50)	0.50 (0.00, 0.50)	0.10 (0.00, 0.17)
		Same	1.00 (0.00, 0.50)	0.00 (0.00, 0.00)	0.00 (*, 0.00)
		Opposite	4.50 (2.50, 2.00)	0.50 (0.00, 0.50)	0.10 (0.00, 0.17)
I	Any	Any	5.50 (1.25, 4.25)	2.25 (0.25, 2.00)	0.38 (0.25, 0.50)
		Same	0.50 (0.25, 0.25)	0.25 (0.00, 0.25)	0.50 (0.00, 1.00)
		Opposite	5.00 (1.00, 4.00)	2.00 (0.25, 1.75)	0.40 (0.50, 0.48)
	Off	Any	5.50 (1.00, 4.50)	2.50 (0.50, 2.00)	0.42 (0.50, 0.50)
		Same	1.00 (0.50, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, *)
		Opposite	5.00 (0.50, 4.50)	2.50 (0.50, 2.00)	0.50 (1.00, 0.50)
	On	Any	5.50 (1.50, 4.00)	2.20 (0.00, 2.00)	0.34 (0.00, 0.50)
		Same	0.00 (0.00, 0.50)	0.50 (0.00, 0.50)	1.00 (*, 1.00)
		Opposite	5.00 (1.50, 3.50)	1.50 (0.00, 1.50)	0.29 (0.00, 0.46)
J	Any	Any	4.00 (0.75, 3.25)	1.50 (0.25, 1.25)	0.41, (0.25, 0.37)
		Same	0.25 (0.00, 0.25)	0.25 (0.00, 0.25)	1.00 (*, 1.00)
		Opposite	3.75 (0.75, 3.00)	1.25 (0.25, 1.00)	0.38 (0.25, 0.33)
	Off	Any	3.50 (0.00, 3.50)	2.00 (0.00, 2.00)	0.57 (*, 0.57)
		Same	0.50 (0.00, 0.50)	0.50 (0.00, 0.50)	1.00 (*, 1.00)
		Opposite	3.00 (0.00, 3.00)	1.50 (0.00, 1.50)	0.50 (*, 0.50)
	On	Any	4.50 (1.50, 3.00)	1.00 (0.50, 0.50)	0.32 (0.25, 0.17)
		Same	0.00 (0.00, 0.00)	0.00 (0.00, 0.50)	* (*, *)
		Opposite	4.50 (1.50, 3.00)	1.00 (0.50, 0.50)	0.32 (0.25, 0.46)

CHAPTER EIGHT

GENERAL DISCUSSION

This thesis presents new data and conclusions about the contact that occurs between dogs, and between dogs and people, in an example pet dog population. The information gained from this thesis will often be specific to the geographic area studied, but aspects may be to some extent generalised to the wider dog population and may help inform new policy, in particular for preventing infectious disease spread in dogs and reducing risk of zoonoses transmission from dogs to people. It also provides useful insights into pet dog behaviour and owner psychology, for those working in dog-related professions, and those interested in companion animal behaviour problems. Available data to these professions is often sparse and heavily biased towards 'problem' dogs that have been referred for treatment, or alternatively is data collected by pet-food companies for marketing purposes, and so there is a lack of baseline data about general pet dogs and how they behave and interact with people.

Chapter 2 confirmed that dogs are particularly common in family households with older children in a UK population too, and it was detailed in Chapter 3 that the dogs studied lived in close contact with their human social group. A number of situations were described, and particular types of dogs may be considered more at risk of performing certain behaviours, or being managed in a particular manner, that facilitates close contact and therefore the possibility of zoonotic disease transmission. Actual risk will of course depend on how the pathogen in question is transmitted, and the prevalence and shedding patterns of viable pathogenic organisms from the animal. The findings from Chapter 3 often did not appear unusual, and were straightforward to explain, for example, that small dogs are more likely to jump up at people and lie on laps, but there is now real data to compliment anecdotal evidence and previous findings from small observational studies. The information should be used to target education efforts, such as to highlight the need for regular health checks with a veterinary surgeon and appropriate preventive disease measures such as vaccination and worming, and to encourage male owners to pick up after their dog and dispose of the faeces appropriately.

We also identified that certain households and their dogs may be influential players in the social networks of dogs and people via walking (Chapter 4), which has implications for the psychological and physical health benefits suggested to be associated with dog ownership. Certain types of dog owners, such as those with multiple dogs, or Working, Pastoral or some terrier breeds, are suggested to be more likely to have longer and more varied dog walks and therefore may be in less need of other types of social support or physical exercise to improve their health, meaning that efforts could be more efficiently targeted to other people in greater need.

The observational studies of dogs being walked provide interesting insight into owner and dog behaviour outside the home, to complement the social network studies (Chapter 4) that only quantified the potential for interaction. The addition of an observational approach also compliments the owner-questionnaire approach previously used. Dogs were far more likely to contact other dogs than people, despite the fact that most dogs are being walked by an owner and thus there are at least the same amount of people available to interact with as dogs. Therefore, providing that owners clear up after their dogs have defaecated, contact between dogs and people met on walks and the subsequent risk of zoonotic disease transmission is very small.

In almost three-quarters of observations (Chapter 6), the subject dogs were not observed to interact with any other dogs. Therefore, the network of theoretical contact between dogs through sharing of public space (Chapter 4) is likely to be further dispersed due to lack of actual physical interactions, even if other dogs are available nearby. However, most dogs performed sniffing behaviour directed at the environment, spending an average one-fifth of their time on the walk on this behaviour. In particular Gundogs were associated with observation of sniffing behaviours compared to other UK Kennel Club Categories. For some pathogens, investigation of excretions and secretions by dogs may cause a significant disease risk in this manner, as discussed in Chapter 4, but quantification of actual risk will depend on the pathogen transmission characteristics, the amount of shedding occurring at the time in the individual, and the specific behaviour of the other dog investigating the excreta.

The observational study of focal dogs in walking areas (Chapter 6) was limited by the fact that it only observed actual interactions and did not quantify potential for interactions. Therefore it could not be said whether a dog who was not observed to interact with any other dogs, chose not to interact with another dog that was present, or just had no opportunities for interaction. In contrast, the experimental observational study (Chapter 7) recorded both the number of dogs available to interact with and the number of interactions that actually occurred. Another limit to the study performed in Chapter 6 was that only some dogs were observed both on lead and off lead, most were only seen off lead. Being able to compare on lead with off lead behaviour is useful to assess how lead use might be used as an intervention strategy to reduce the numbers of interactions or nature of these interactions. In contrast, the experimental study reported in Chapter 7 observed each dog both on and off lead, under controlled conditions, and suggested that putting dogs on a lead may substantially reduce the number of interactions that occur between dogs, and most likely people too.

The main studies in this thesis were designed to investigate how contact between dogs and between dogs and people might impact on disease spread, in particular zoonoses, but with no specific infectious disease in mind. However, opportunity arose to sample the faeces from dogs in the survey, and these samples were then screened for *Campylobacter* spp. carriage. The analysis performed using the wealth of management and behaviour data for these dogs provided a new and detailed perspective on how these lifestyle factors may impact on carriage of a zoonotic disease in pet dogs, and identified potentially modifiable risk factors of use (Chapter 5), that we have quantified in an example pet dog community (Chapter 3). For example, it is suggested that feeding the dog human food leftovers in his bowl, or commercial dog treats, or even sharing a household with pet fish, may increase the risk of *C. upsaliensis* carriage, and these avenues require further investigation.

The fact that 25% of the dogs were shown to be carriers of *C. upsaliensis* provides evidence to substantiate the importance of investigating pet dog-human interactions in relation to zoonotic disease risk and makes the information gained during this thesis, in particular the close dog-owner contact described in Chapter 3, even more pertinent. However, the dogs were apparently healthy and no associations were found between carriage and vomiting or diarrhoea, which suggests that the presence of *Campylobacter* spp. was not causing clinical problems in the dogs. Therefore it may also be reasonable to suggest that these dogs are of limited risk to their owners and other household members in terms of causing clinical disease. In terms of human health, *Campylobacter jejuni* is the most frequently isolated species from humans, followed by *C. coli* (Lastovica and Le Roux 2001, 2003; Lopez and others 1998) whereas as *C. jejuni* and *C. coli* were rarely detected in the dogs (although only examined by culture methods in contrast to *C. upsaliensis* also by direct PCR from faeces) and so this also indicates that the dogs were probably not a significant health risk to humans. It would be of great benefit for similarly detailed, prevalence and risk factor studies, to be undertaken for other possible zoonotic pathogens in pet dogs. Although we conclude that transmission of *Campylobacter* spp. is unlikely to be a considerable health risk from owning dogs, this may not be the case with other pathogens, and they should be investigated individually and appropriately, and evaluated in terms of clinical risk to both humans and to the animal itself.

The information presented here is also relevant to the study of non-zoonotic infectious disease transmission within the pet-dog population. We have demonstrated that the dogs in this area were part of a large, highly connected social network (Chapter 4) and in some cases had considerable potential contact with other dogs via direct and indirect interactions (Chapter 4, 6 and 7). This information should be used to substantiate the need for vaccination and other preventive disease measures, as many pet dogs will have a higher potential for contact with other dogs than may be immediately apparent to the owner. In the face of disease outbreak, it is feasible that on lead laws could be recommended as an effective method of reducing the number of contacts.

This thesis focused on a relatively small population of dogs, in the Wirral and Cheshire, UK. Therefore, much care should be taken when generalising our findings to the wider population of UK pet dogs (and even other similar countries). The areas used in the observational studies were popular and busy dog walking areas found near socio-economically high standard towns and villages in a semi-rural area, and are therefore likely to be frequented by particular types of dogs and owners, which may have biased the data towards more 'friendly' dogs that interact more readily. In addition, the Wirral and Cheshire regions in general are not comparable to, for example, the inner area of a large city, in terms of socio-economic status of residents or types and breeds of dogs owned, and these factors will both affect the way that owners manage their dogs and the way a dog behaves. It must also be noted that whenever considering 'dog types', although based on UK Kennel Club Categories, these are themselves rather arbitrary groupings, and individual breed types are also likely to vary considerably in the way that they behave and are managed by owners, in addition to variation at the level of the individual dog and owner.

The 'small rural town' nature of the questionnaire survey area is likely to have its own particulars and characteristics, and so will the Wirral and Cheshire areas in comparison to other regions, (for example maybe the association of horse and dog ownership), but similar communities are found commonly in other areas of the UK. The strength of this study approach in comparison to previous research is that the "Dogs in the Community Survey" recruited almost all dogs living in the contained geographic area, so that the contact network between essentially all the dogs living there could be constructed (Chapter 4). It therefore did not only include dogs that visit the vet, or owners that were particularly dog-lovers and volunteered themselves. For example, the sixteen percent of dogs that were reported to have not visited the vet in the past year may have been missed by a more traditional recruitment method. The focussed nature of the survey allowed the participants to be studied in much greater detail than has been previously undertaken, in terms of the dog's lifestyle, management, behaviours and contacts. It will therefore be a useful resource for anyone interested in an example of how pet dogs are owned and managed; for example only 62% of dogs were reported to have had vaccinations in the past year, which may mean that there is less than the recommended coverage for vaccine efficacy for a particular disease.

The challenge of quantifying the risk of zoonoses transmission to people from companion animals such as dogs requires further investigation. It is likely that the risk is small compared to that from other sources such as undercooked food. However, the work of this thesis has described the close relationship that people can have with their pet dogs and the varied opportunities for close contact that occur on a regular basis, of which disease transmission might occur if an infection was present. Actual risk will vary depending on the exact pathogen, host susceptibility and transmission dynamics. However, the need for good hygiene practices, common sense and excellent preventive healthcare measures is implicated, especially for those owners whose dogs have contact with the young, elderly or otherwise immunocompromised.

Although the 'average' pet dog incorporates the majority of dogs in society, some working dogs will have an even greater contact with people. The facilitation of social contact produced by the presence of a dog was discussed in Chapter 1, and this is particularly relevant to recipients of Assistance Dogs and Service Dogs. In this situation, the effect could be further increased by identification as an assistance dog and the novelty of meeting a dog in a usually non-dog situation such as in shops or restaurants. Personal experience of Hearing Dogs at work suggests common touching and petting from strangers in otherwise dog-free places such as supermarkets and cafes, in addition to particularly close physical contact with their recipient. Hearing dogs in training and socialisation in the UK have been screened for campylobacter and endoparasite carriage (Guest and others 2007). Prevalences of 15-31% *Campylobacter* spp., 0-3% Coccidia, 2-13% Giardia, 1-5% hookworm and 2-4% Toxocara were reported. It must also be noted that Hearing Dog recipients are often elderly and/or disabled and may have weakened immune systems, rendering them vunerable to infection.

Another example of dogs introduced into environments where pet dogs may not normally be seen is in the case of therapy dogs, known as PAT dogs in the UK. The practice of taking visiting animals into nursing homes is perhaps the best known example, although this type of therapy is also used with people with other special needs (Hart 1995a). A survey of US and Canadian societies with AAT (Animal Assisted Therapy) programs reported 94% using dogs (Waltner-Toews 1993). Of these programs two-thirds visited elderly nursing homes, a quarter schools and a quarter hospitals. The societies were questioned about their knowledge and policies on zoonotic disease prevention; less than half of the community based programs involved a healthcare professional but 95% of hospital programs did. Some of the groups also had misconceptions about zoonotic diseases and their control, even choosing to use puppies and kittens which are in fact less safe in relation to most parasitic and bacterial diseases. Despite disease risk concerns, animals have a profound role for therapy and assistance to persons with disabilities.

More research is needed to better elucidate the role of dog-dog and dog-human contacts in disease spread. In particular it should evaluate pathogen-specific contacts, in order to further clarify the actual risk. It would also be beneficial to perform observational studies of dogs in the home, to complement the questionnaire-based investigations presented here, and also to further investigate the effect of lead use, in particular if there in differences in the behavioural nature of on lead and off lead interactions. The study on risk factors for *C. upsaliensis* carriage indicated that fish ponds, tanks and commercial dog treats need to be investigated further as a possible source of infection.

Our work was limited to a minute subset of the UK pet dog population and so more studies are required, in other areas, different countries, and across larger sample populations, in particular to assess aspects such as breed differences which cannot be done without larger numbers of subjects. It is encouraging to note that the work of Heller (2007) seems to be producing similar findings in Scotland (Heller and others 2007), and I support their additional approach of investigating the current knowledge and education levels of dog owners about zoonotic potential and disease risk. The work within this thesis is only a small contribution towards the amount still to be discovered about the dog-human relationship. Particularly notable is the remarkable amount of variation in both owner and dog behaviour observed here in just this small sample population. This illustrates the substantial and extraordinary role that dogs play in human society, and the special place that they occupy in many people's lives, including mine.

REFERENCES

ACKE, E., WHYTE, P., JONES, B. R., MCGILL, K., COLLINS, J. D. & FANNING, S. (2006) Prevalence of thermophilic Campylobacter species in cats and dogs in two animal shelters in Ireland. Veterinary Record 158, 51-54

ADAK, G. K., COWDEN, J. M., NICHOLAS, S. & EVANS, H. S. (1995) The Public Health Laboratory Service national case-control study of primary indigenous sporadic cases of campylobacter infection. Epidemiology and Infection 115, 15-22

ALBERT, A. & BULCROFT, K. (1987) Pets and urban life. Anthrozoos 1, 9-23

ALBERT, R., JEONG, H. & BARABASI, A. L. (2000) Error and attack tolerance of complex networks. Nature 406, 378-382

ALHAKAMI, A. S. & SLOVIC, P. (1994) A psychological study of the inverse relationship between perceived risk and perceived benefit. Risk Analysis 14, 1085-1096

ALTEKRUSE, S. F., STERN, N. J., FIELDS, P. I. & SWERDLOW, D. L. (1999) Campylobacter jejuni--an emerging foodborne pathogen. Emerging Infectious Diseases 5, 28-35

ALTEKRUSE, S. F. & TOLLEFSON, L. K. (2003) Human campylobacteriosis: a challenge for the veterinary profession. Journal of the American Veterinary Medical Association 223, 445-452

ANGULO, F. J., GLASER, C. J., JURANEK, D. D., LAPPIN, M. R. & REGNERY, R. L. (1994) Caring for pets of immunocompromised persons. Journal Of The American Veterinary Medical Association 205, 1711-1718

ANON (1991) A consumer survey of 17 European countries. London, Readers Digest Eurodata

ANON (2000) WHO Campylobacter factsheet. http://www.who.int/mediacentre/factsheets/fs255/en/Access, 2000

ANON (2004a) American Pet Products Manufacturers Association- National Pet Owners Survey. Scarsdale NY, NFO Research Inc

ANON (2004b) Pet Food Manufacturers Association. Pet ownership trends. http://www.pfma.com/public/petownership.htmAccess, 2004b

BAKER, J., BARTON, M. D. & LANSER, J. (1999) Campylobacter species in cats and dogs in South Australia. Australian Veterinary Journal 77, 662-666

BANSAL, S., GRENFELL, B. T. & MEYERS, L. A. (2007) When individual behaviour matters: homogenous and network models in epidemiology. Journal Of The Royal Society Interface, 879-891

BAPTISTE, K. E., WILLIAMS, K., WILLAMS, N. J., WATTRET, A., CLEGG, P. D., DAWSON, S., CORKILL, J. E., O'NEILL, T. & HART, C. A. (2005) Methicillin-resistant staphylococci in companion animals. Emerging Infectious Diseases 11, 1942-1944

BARABÁSI, A. L. & ALBERT, R. (1999) Emergence of scaling in random networks. Science 286, 509-511

BARKER, S. B. & BARKER, R. T. (1988) The human-canine bond: closer than family ties? Journal of Mental Health Counselling, 46-56

BAUMAN, A. E., RUSSELL, S. J., FURBER, S. E. & DOBSON, A. J. (2001) The epidemiology of dog walking: an unmet need for human and canine health. Medical Journal of Australia 175, 632-634

BBC (2007) Stray dog numbers rise by a fifth. http://news.bbc.co.uk/1/hi/england/west_midlands/6312641.stmAccess, 2007

BEAVER, B. V. (1994) Owner complaints about canine behaviour. Journal Of The American Veterinary Medical Association 204, 1953-1955

BECK, A. M. (1973) The ecology of stray dogs: a study of free-ranging urban animals. Baltimore, MD, York Press

BECK, A. M. & MEYERS, N. M. (1996) Health enhancement and companion animal ownership. Annual Review Of Public Health 17, 247-257

BEKOFF, M. & MEANEY, C. A. (1997) Interactions among dogs, people, and the environment in Boulder, Colorado: A case study. Anthrozoos 10, 23-31

BOITANI, L., FRANCISCI, P., CIUCCI, P. & ANDREOLI, G. (1995) Population biology and ecology of feral dogs in central Italy. In The domestic dog: its evolution, behaviour and interactions with people. Ed J. SERPELL. Cambridge, Cambridge University Press. pp 217-244

BORGATTI, S. P. & EVERETT, M. G. (1997) Network analysis of 2-mode data. Social Networks 19, 243-269

BORGATTI, S. P., EVERETT, M.G. AND FREEMAN, L.C. (2002) Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies.

BRADLEY, J. (2005) Dogs bite: but balloons and slippers are more dangerous., James and Kenneth

BRADSHAW, J. W. S. & LEA, A. M. (1992) Dyadic interactions between domestic dogs. Anthrozoos 5, 245-253

BRADSHAW, J. W. S. & NOTT, H. M. R. (1995) Social and communication behaviour of companion dogs. In The domestic dog: its evolution, behaviour and interactions with people. Ed J. SERPELL. Cambridge, Cambridge University Press. pp 115-130

BRAND, U. (2002) Comparative survey of dog owners in Berlin and Brandenburg, Germany. Tierarztliche Umschau 57, 309-316

BRIESEMAN, M. A. (1990) A further study of the epidemiology of Campylobacter jejuni infections. New Zealand Medical Journal 103, 207-209

BRODIE, J. D. (1981) Health benefits of owning pet animals. Veterinary Record 109, 197-199

BRYANT, B. K. (1990a) The richness of the child-pet relationship: a consideration of both benefits and costs of pets to children. Anthrozoos 3, 253-261

BRYANT, B. K. (1990b) The richness of the child-pet relationship:a consideration of both benefits and costs of pets to children. Anthrozoos, 253-261

BUGG, R. J., ROBERTSON, I. D., ELLIOT, A. D. & THOMPSON, R. C. A. (1999) Gastrointestinal parasites of urban dogs in Perth, Western Australia. Veterinary Journal 157, 295-301

BURCH, M. R., BUSTAD, L. K., DUNCAN, S. L., FREDERICKSON, M. & TEBAY, J. (1995) The role of pets in therapeutic programs. In The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership
Ed I. ROBINSON. Oxford, Elsevier Science Ltd
pp 55-69

BURNENS, A. P., ANGELOZ-WICK, B. & NICOLET, J. (1992) Comparison of Campylobacter carriage rates in diarrheic and healthy pet animals. Zentralbl Veterinarmed B 39, 175-180

BUSTAD, L. K., HINES, L.M. (1983) Placement of animals with the elderly: benefits and strategies. In New perspectives on our lives with companion animals. Ed A. H. KATCHER, BECK A.M. Philadelphia, University of Pennsylvania Press. pp 291-302

CAMERAS4SPORTS (2007) 480 Land and Air Helmet Cam. http://www.cameras4sports.co.uk/product.asp?id=352Access, 2007

CEFAI, C., ASHURST, S. & OWENS, C. (1994) Human Carriage Of Methicillin-Resistant Staphylococcus-Aureus Linked With Pet Dog. Lancet 344, 539-540

CHRISTLEY, R. M. & FRENCH, N. P. (2003) Small-world topology of UK racing: the potential for rapid spread of infectious agents. Equine Veterinary Journal 35, 586-589

CHRISTOPHER, P. J., CLAXTON, P. D., DORMAN, D. C., OCONNOR, B. F., PROUDFOR.RW & SUTTON, R. G. A. (1974) Salmonellosis - Increasing Health Hazard. Medical Journal Of Australia 1, 337-341

CLUTTON-BROCK, J. (1995) Origins of the dog. In The domestic dog: its evolution, behaviour and interactions with people. Ed J. SERPELL. Cambridge, Cambridge University Press. pp 7-20

CMM (2006) MLwiN. 2.02 edn. University of Bristol, Centre for Multilevel Modelling

CORNER, L. A. L., PFEIFFER, D. U. & MORRIS, R. S. (2003) Social-network analysis of Mycobacterium bovis transmission among captive brushtail possums (Trichosurus vulpecula). Preventive Veterinary Medicine 59, 147-167

CRAWLEY, M. J. (2007) Changing the look of graphics. In The R Book. Ed M. J. CRAWLY. Chichester, John Wiley and Sons. pp 827-872

DEFRA (2006) Zoonoses Report United Kingdom 2005. DEPARTMENT FOR ENVIRONMENT FOOD AND RURAL AFFAIRS.

DOTY, R. L. & DUNBAR, I. (1974) Attraction of Beagles to Conspecific Urine, Vaginal and Anal Sac Secretion Odors. Physiology & Behavior 12, 825-833

EGERTON, J. R. (1982) Pets And Zoonoses. Medical Journal Of Australia 2, 311-311

ENDENBURG, N. & BAARDA, B. (1995) The role of pets in enhancing human well-being: effects on child development. In The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership. Ed I. ROBINSON. Oxford, Elsevier Science Ltd. pp 7-17

ENGBERG, J. (2006) Contributions to the epidemiology of Campylobacter infections - A review of clinical and microbiological studies. Danish Medical Bulletin 53, 361-389

ENGVALL, E. O., BRANDSTROM, B., ANDERSSON, L., BAVERUD, V., TROWALD-WIGH, G. & ENGLUND, L. (2003) Isolation and identification of thermophilic Campylobacter species in faecal samples from Swedish dogs. Scandanavian Journal of Infectious Diseases 35, 713-718

FELDMANN, B. M. (1997) Why people own pets - Pet owner psychology and the deliquent owner. Animal Regulation Studies 1, 87-94

FERNANDEZ, H. & MARTIN, R. (1991) Campylobacter intestinal carriage among stray and pet dogs. Revista De Saude Publica 25, 473-475

FISHER, J. (2001) The dog in the human pack. In Think Dog! London, Cassell & Co. pp 25-36

FLEMING, M. P. (1983) Association of Campylobacter jejuni with enteritis in dogs and cats. Veterinary Record 113, 372-374

FOX, M. W. (1984) The comparative ethology of the domesticated dog. In Behaviour of Wolves Dogs and Related Canids. Malabar, Florida, Krieger. p 186

FRANTI, C. E. & KRAUS, J. F. (1974) Aspects of pet ownership in Yolo-County California. Journal Of The American Veterinary Medical Association 164, 166-171

FRANTI, C. E., KRAUS, J. F., BORHANI, N. O., JOHNSON, S. L. & TUCKER, S. D. (1980) Pet ownership in rural Northern California (El-Dorado County). Journal Of The American Veterinary Medical Association 176, 143-149

FRIEDMAN, S. R. & ARAL, S. (2001) Social networks, risk-potential networks, health, and disease. Journal Of Urban Health-Bulletin Of The New York Academy Of Medicine 78, 411-418

FRIEDMANN, E. (1995) The role of pets in enhancing human well-being: physiological effects. In The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership. Ed I. ROBINSON. Oxford, Elsevier Science Ltd. pp 33-53

FRIEDMANN, E., KATCHER, A. H., LYNCH, J. J. & THOMAS, S. A. (1980) Animal companions and one-year survival of patients after discharge from a coronary-care unit. Public Health Reports 95, 307-312

FRIEDMANN, E. & THOMAS, S. A. (1995) Pet ownership, social support, and one-year survival after Acute Myocardial Infarction in the Cardiac Arrhythmia Suppression Trial (CAST). American Journal of Cardiology 76, 1213-1217

FROST, J. A. (2001) Current epidemiological issues in human campylobacteriosis. Proceedings of the Society for Applied Microbiology Symposium, 85S-95S

FUKATA, T., NAITO, F., YOSHIDA, N., YAMAGUCHI, T., MIZUMURA, Y. & HIRAI, K. (2002) Incidence of Salmonella infection in healthy dogs in Gifu Prefecture, Japan. Journal of Veterinary Medical Science 64, 1079-1080

GEFFRAY, L. & PARIS, C. (2001) Infectious risks associated with pets. Medecine Et Maladies Infectieuses 31, 126S-142S

GHANI, A. C., SWINTON, J. & GARNETT, G. P. (1997) The role of sexual partnership networks in the epidemiology of gonorrhea. Sexually Transmitted Diseases 24, 45-56

GILLESPIE, I. A., O'BRIEN, S. J., ADAK, G. K., TAM, C. C., FROST, J. A., BOLTON, F. J. & TOMPKINS, D. S. (2003) Point source outbreaks of Campylobacter jejuni infection--are they more common than we think and what might cause them? Epidemiology and Infection 130, 367-375

GLASER, C. A., ANGULO, F. J. & ROONEY, J. A. (1994) Animal-Associated Opportunistic Infections among Persons Infected with the Human-Immunodeficiency-Virus. Clinical Infectious Diseases 18, 14-24

GLICKMAN, L. T. (1990) Toxocariasis and related syndromes. In Tropical and geographic medicine. Eds K. S. WARREN, A. A. F. MAHMOUD. New York, McGraw-Hill. pp 446-455

GREENE, C. E. (2006) Environmental factors in infectious disease. In Infectious Diseases of the Dog and Cat. Ed C. E. GREENE. St.Louis, Saunders Elsevier. pp 991-1013

GREENE, C. E. & LEVY, J. K. (2006) Immunocompromised people and shared human and animal infections: zoonoses, sapronoses and anthroponoses. In Infectious Diseases of the Dog and Cat. Third edn. Ed C. E. GREENE. St. Louis, Missouri, Saunders Elsevier. pp 1051-1068

GUEST, C. M., STEPHEN, J. M. & PRICE, C. J. (2007) Prevalence of Campylobacter and four endoparasites in dog populations associated with hearing dogs. Journal of Small Animal Practice 48, 631-637

GUY, N. C., LUESCHER, U. A., DOHOO, S. E., SPANGLER, E., MILLER, J. B., DOHOO, I. R. & BATE, L. A. (2001) Risk factors for dog bites to owners in a general veterinary caseload. Applied Animal Behaviour Science 74, 29-42

HACKETT, T. & LAPPIN, M. R. (2003) Prevalence of enteric pathogens in dogs of north-central Colorado. Journal of the American Animal Hospital Association 39, 52-56

HALD, B. & MADSEN, M. (1997) Healthy puppies and kittens as carriers of *Campylobacter* spp., with special reference to *Campylobacter upsaliensis*. Journal of Clinical Microbiology 35, 3351-3352

HALD, B., PEDERSEN, K., WAINO, M., JORGENSEN, J. C. & MADSEN, M. (2004) Longitudinal study of the excretion patterns of thermophilic Campylobacter spp. in young pet dogs in Denmark. Journal of Clinical Microbiology 42, 2003-2012

HART, L. A. (1995a) Dogs as human companions: a review of the relationship. In The domestic dog: its evolution, behaviour and interactions with people. Ed J. SERPELL. Cambridge, Cambridge University Press. pp 162-178

HART, L. A. (1995b) The role of pets in enhancing human well-being: effects for older people. In The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership. Ed I. ROBINSON. Oxford, Elsevier Science Ltd. pp 19-31

HART, L. A., ZASLOFF, R. L. & BENFATTO, A. M. (1996) The socializing role of hearing dogs. Applied Animal Behaviour Science 47, 7-15

HEADEY, B. (2003) Pet ownership: good for health? Medical Journal Of Australia 179, 460-461

HEAEDY, B., GRABKA, M., KELLEY, J., REDDY, P. & TSENG, Y. (2002) Pet ownership is good for your health and saves public expenditure too: Australian and German longitudinal evidence. Australian Social Monitor 4, 93-99

HELLER, J., HYDEN, B., BIERBAUM, S., REID, S. W. J. & MELLOR, D. J. (2007) It's me or the dog - A questionnaire study of canine-human interactions in Scotland. In European College of Veterinary Public Health. Helsinki, Finland

HUNTHAUSEN, W. & SEKSEL, K. (2002) Preventive behavioural medicine. In BSAVA Manual of Canine and Feline Behavioural Medicine. Eds D. F. HORWITZ, D. S. MILLS, S. HEATH. Gloucester, British Small Animal Veterinary Association. pp 49-60

IKEDA, Y., NAKAMURA, K., MIYAZAWA, T., TOHYA, Y., TAKAHASHI, E. & MOCHIZUKI, M. (2002) Feline host range of Canine parvovirus: Recent emergence of new antigenic types in cats. Emerging Infectious Diseases 8, 341-346

JACKSON, T. (2005) Is it time to ban dogs as household pets? BMJ 331, 1278-

JAGOE, A. & SERPELL, J. (1996) Owner characteristics and interactions and the prevalence of canine behaviour problems. Applied Animal Behaviour Science 47, 31-42

KAO, R. R., DANON, L., GREEN, D. M. & KISS, I. Z. (2006) Demographic structure and pathogen dynamics on the network of livestock movements in Great Britain. Proceedings Of The Royal Society B-Biological Sciences 273, 1999-2007

KARENLAMPI, R. I., TOLVANEN, T. P. & HANNINEN, M. L. (2004) Phylogenetic analysis and PCR-restriction fragment length polymorphism identification of Campylobacter species based on partial groEL gene sequences. J Clin Microbiol 42, 5731-5738

KATCHER, A. H. (1981) Interactions between people and their pets: form and function. In Interrelations between people and pets. Ed B. FOGLE. Springfield, Charles C. Thomas. pp 41-67

KATCHER, A. H. & FRIEDMANN, E. (1982) Potential health value of pet ownership. California Veterinarian 36, 9-13

KELLER, E. F. (2005) Revisiting "scale-free" networks. Bioessays 27, 1060-1068

KITALA, P., MCDERMOTT, J., KYULE, M., GATHUMA, J., PERRY, B. & WANDELER, A. (2001) Dog ecology and demography information to support the planning of rabies control in Machakos District, Kenya. Acta Tropica 78, 217-230

KLOVDAHL, A. S., POTTERAT, J. J., WOODHOUSE, D. E., MUTH, J. B., MUTH, S. Q. & DARROW, W. W. (1994) Social networks and infectious disease: the Colorado Springs Study. Social Science & Medicine 38, 79-88

KNOTT, L. (2007) Dog bites. www.patient.co.uk/showdoc/40026056/Access, 2007

KOBELT, A. J., HEMSWORTH, P. H., BARNETT, J. L. & COLEMAN, G. J. (2003) A survey of dog ownership in suburban Australia - conditions and behaviour problems. Applied Animal Behaviour Science 82, 137-148

LACEY, H. (1994) This foul mess. In Independent on Sunday

LANDSBERG, G., HUNTHAUSEN, W. & ACKERMAN, L. (2003) In Handbook of behaviour problems of the dog and cat. 2nd edn. Edinburgh, Saunders. p 49

LASTOVICA, A. J. & LE ROUX, E. (2001) Efficient isolation of Campylobacter upsaliensis from stools. Journal of Clinical Microbiology 39, 4222-4222

LASTOVICA, A. J. & LE ROUX, E. (2003) Prevalence and optimal detection of C-upsaliensis in stool specimens. Clinical Infectious Diseases 36, 1624-1625

LEJEUNE, J. T. & HANCOCK, D. D. (2001) Public health concerns associated with feeding raw meat diets to dogs. Journal Of The American Veterinary Medical Association 219, 1222-1225

LESLIE, B. E., MEEK, A. H., KAWASH, G. F. & MCKEOWN, D. B. (1994) An epidemiologic investigation of pet ownership in Ontario. Canadian Veterinary Journal-Revue Veterinaire Canadienne 35, 218-222

LEVINSON, B. (1969) Pet oriented child psychotherapy, Springfield

LEVINSON, B. (1972) Pets and human development, Springfield

LINTON, D., LAWSON, A. J., OWEN, R. J. & STANLEY, J. (1997) PCR detection, identification to species level, and fingerprinting of Campylobacter jejuni and Campylobacter coli direct from diarrheic samples. J Clin Microbiol 35, 2568-2572

LINTON, D., OWEN, R. J. & STANLEY, J. (1996) Rapid identification by PCR of the genus Campylobacter and of five Campylobacter species enteropathogenic for man and animals. Res Microbiol 147, 707-718

LOEFFLER, A., BOAG, A. K., SUNG, J., LINDSAY, J. A., GUARDABASSI, L., DALSGAARD, A., SMITH, H., STEVENS, K. B. & LLOYD, D. H. (2005) Prevalence of methicillin-resistant Staphylococcus aureus among staff and pets in a small animal referral hospital in the UK. Journal of Antimicrobial Chemotherapy 56, 692-697

LOPEZ, C. M., GIACOBONI, G., AGOSTINI, A., CORNERO, F. J., TELLECHEA, D. M. & TRINIDAD, J. J. (2002) Thermotolerant Campylobacters in domestic animals in a defined population in Buenos Aires, Argentina. Preventive Veterinary Medicine 55, 193-200

LOPEZ, L., CASTILLO, F. J., CLAVEL, A. & RUBIO, M. C. (1998) Use of a selective medium and a membrane filter method for isolation of Campylobacter species from Spanish paediatric patients. European Journal of Clinical Microbiology & Infectious Diseases 17, 489-492

LUSSEAU, D. (2003) The emergent properties of a dolphin social network. Proceedings Of The Royal Society Of London Series B-Biological Sciences 270, S186-S188

MACDONALD, A. (1981) The pet dog in the home: a study of interactions. In Interrelations between people and pets. Ed B. FOGLE. Springfield, Charles C Thomas. pp 195-206

MANIAN, F. A. (2003) Asymptomatic nasal carriage of mupirocin-resistant, methicillin-resistant Staphylococcus aureus (MRSA) in a pet dog associated with MRSA infection in household contacts. Clinical Infectious Diseases 36, E26-E28

MARRON, J. A. & SENN, C. L. (1974) Dog feces, a public health and environmental problem. Journal Of Environmental Health 37, 239-243

MARTIN, P. & BATESON, B. (1993a) Recording methods. In Measuring Behaviour: An introductory guide. Second Edition edn. Eds P. MARTIN, B. BATESON. Cambridge, Cambridge University Press. pp 84-100

MARTIN, P. & BATESON, B. (1993b) The reliabilty and validity of measures. In Measuring Behaviour: An introductory guide. Second Edition edn. Eds P. MARTIN, B. BATESON. Cambridge, Cambridge University Press. pp 114-124

MARTIN, P. & BATESON, B. (1993c) Research design. In Measuring Behaviour: An introductory guide. Second Edition edn. Eds P. MARTIN, B. BATESON. Cambridge, Campbridge University Press. pp 25-55

MATTER, H. C., WANDELER, A. I., NEUENSCHWANDER, B. E., HARISCHANDRA, L. P. A. & MESLIN, F. X. (2000) Study of the dog population and the rabies control activities in the Mirigama area of Sri Lanka. Acta Tropica 75, 95-108

MAY, R. M. (2006) Network structure and the biology of populations. Trends in Ecology & Evolution 21, 394-399

MCHARG, M., BALDOCK, C., HEADEY, B. & ROBINSON, A. (1995) National people and pets survey. Australia, Urban Animal Management Coalition

MCNICHOLAS, J. & COLLIS, G. M. (2000) Dogs as catalysts for social interactions: Robustness of the effect. British Journal Of Psychology 91, 61-70

MCNICHOLAS, J., GILBEY, A., RENNIE, A., AHMEDZAI, S., DONO, J.-A. & ORMEROD, E. (2005) Pet ownership and human health: a brief review of evidence and issues. BMJ 331, 1252-1254

MEEK, P. D. (1999) The movement, roaming behaviour and home range of free-roaming domestic dogs, Canis lupus familiaris, in coastal New South Wales. Wildlife Research 26, 847-855

MESSENT, P. R. (1983) Social facilitation of contact with other people by pet dogs. In New perspectives on our lives with companion animals. Ed A. H. KATCHER, BECK A.M. Philadelphia
University of Pennsylvania Press. pp 37-46

MESSENT, P. R. (1984) Correlates and effects of pet ownership. In The pet connection: Its influence on our health and quality of life. Eds R. K. ANDERSON, B. L. HART, L.

A. HART. Minneapolis, Center to study Human-Animal Relationships and Environments, University of Minnesota. pp 331-340

MICROSOFT (2003) Microsoft Office Excel.

MIKLOSI, A., TOPAL, J. & CSANYI, V. (2004) Comparative social cognition: what can dogs teach us? Animal Behaviour 67, 995-1004

MILLER, M. & LAGO, D. (1990) Observed pet-owner in-home interactions: species differences and association with the pet relationship scale. Anthrozoos 4

MILLOT, J. L. & FILIATRE, J. C. (1986) The behavioral sequences in the communication system between the child and his pet dog. Applied Animal Behaviour Science 16, 383-390

MINITAB.INC (2005) Minitab release 14.2.

MORENO, G. S., GRIFFITHS, P. L., CONNERTON, I. F. & PARK, R. W. (1993) Occurrence of campylobacters in small domestic and laboratory animals. Journal of Applied Bacteriology 75, 49-54

MORSE, E. V. & DUNCAN, M. A. (1975) Canine Salmonellosis - Prevalence, epizootiology, signs, and public health significance. Journal Of The American Veterinary Medical Association 167, 817-820

MUGFORD, R. A. & MCCOMISKY, J. G. (1975) Some recent work on the psychotherapeutic value or caged birds with old people. In Pets, animals and society. Ed R. S. ANDERSON. London, Balliere Tindall. pp 54-65

MURPHY, C., CARROLL, C. & JORDAN, K. N. (2006) Environmental survival mechanisms of the foodborne pathogen Campylobacter jejuni. Journal of Applied Microbiology 100, 623-632

NAIR, G. B., SARKAR, R. K., CHOWDHURY, S. & PAL, S. C. (1985) Campylobacter infection in domestic dogs. Veterinary Record 116, 237-238

NIELSEN, J. A. & DELUDE, L. A. (1989) Behaviour of young children in the presence of different kinds of animals. Anthrozoos 3, 119-129

NOLDUS (2004) Pocket Observer. 2.0 edn

NOLDUS (2006) ObserverXT. 6.0 edn

OPPENHEIM, A. N. (1992) Questionnaire Planning. In Questionnaire Design, Interviewing and Attitude Measurement. 2nd edn. London, Cassell. pp 100-117

OFFICE FOR NATIONAL STATISTICS. (2001a) National Statistics.

OFFICE FOR NATIONAL STATISTICS. (2001b) National Statistics Socio-economic Classification - All People (KS14A) Riverside Ward.
http://www.neighbourhood.statistics.gov.uk/dissemination/LeadTableView.do?a=3&b=

5948062&c=CH64+0TW&d=14&e=15&f=21&g=428603&i=1001x1003x1004x1005&l=41&o=1&m=0&r=0&s=1211541595687&enc=1

PACE, P. J., SILVER, K. J. & WISNIEWSKI, H. J. (1977) Salmonella in commercially produced dried dog food - Possible relationship to a human infection caused by Salmonella Enteritidis Serotype Havana. Journal Of Food Protection 40, 317-321

PAL, S. K. (2003) Urine marking by free-ranging dogs (Canis familiaris) in relation to sex, season, place and posture. Applied Animal Behaviour Science 80, 45-59

PFMA (2004) Pet Food Manufacturers Association. Pet ownership trends. http://www.pfma.com/public/petownership.htmAccess, 2004

RASBACH, J., BROWNE, W., GOLDSTEIN, H., YANG, M., PLEWIS, I., HEALY, M., WOODHOUSE, G., DRAPER, D., LANGOFRD, I. & LEWIS, T. (2000) A USer's Guide to MLwiN. London, Institute of Education

R DEVELOPMENT CORE TEAM. (2006) R: A language and environment for statistical computing. Vienna, Austria., R Foundation for Statistical Computing

ROBERTSON, I. D., IRWIN, P. J., LYMBERY, A. J. & THOMPSON, R. C. A. (2000) The role of companion animals in the emergence of parasitic zoonoses. International Journal For Parasitology 30, 1369-1377

ROBERTSON, I. D., SHAW, S. E. & CLARK, W. T. (1991) The use of health management practices by a randomly selected group of dog owners in Perth. Australian Veterinary Practitioner 21, 126-130

ROBINSON, R. A. & PUGH, R. N. (2002) Dogs, zoonoses and immunosuppression. Journal Of The Royal Society For The Promotion Of Health 122, 95-98

ROBINSON, S. E. & CHRISTLEY, R. M. (2007) Exploring the role of auction markets in cattle movements within Great Britain. Preventive Veterinary Medicine 81, 21-37

ROBINSON, S. E., EVERETT, M. G. & CHRISTLEY, R. M. (2007) Recent network evolution increases the potential for large epidemics in the British cattle population. Journal Of The Royal Society Interface 4, 669-674

ROONEY, N. J., BRADSHAW, J. W. S. & ROBINSON, I. H. (2000) A comparison of dog-dog and dog-human play behaviour. Applied Animal Behaviour Science 66, 235-248

ROONEY, N. J., BRADSHAW, J. W. S. & ROBINSON, I. H. (2001) Do dogs respond to play signals given by humans? Animal Behaviour 61, 715-722

ROSSI, M., HANNINEN, M. L., REVEZ, J., HANNULA, M. & ZANONI, R. G. (2008) Occurrence and species level diagnostics of Campylobacter spp., enteric

Helicobacter spp., and Anaerobiospirillum spp. in healthy and diarrheic dogs and cats. Veterinary Microbiology 129, 304-314

RUBIN, D., SEGAL, S. & MARTINDALE, J. (1976) Contamination of soil in two city parks with canine nematode ova including *Toxocara canis*: A preliminary study. American Journal of Public Health 65, 1242-1245

RUBIN, H. D. & BECK, A. M. (1982) Ecological behaviour of free-ranging urban pet dogs. Applied Animal Ethology 8, 161-168

SAEED, A. M., HARRIS, N. V. & DIGIACOMO, R. F. (1993) The role of exposure to animals in the etiology of Campylobacter-Jejuni-Coli Enteritis. American Journal of Epidemiology 137, 108-114

SALFIELD, N. J. & PUGH, E. J. (1987) Campylobacter enteritis in young children living in households with puppies. British Medical Journal (Clinical Research Edition) 294, 21-22

SAMPSON, W. W. (1984) The urban canine - pet ... Disease vector ... Safety hazard ... Nuisance. Journal Of Environmental Health 46, 306-310

SANDBERG, M., BERGSJO, B., HOFSHAGEN, M., SKJERVE, E. & KRUSE, H. (2002) Risk factors for Campylobacter infection in Norwegian cats and dogs. Preventive Veterinary Medicine 55, 241-253

SCOTT, J. P. & FULLER, J. L. (1965) Genetics and social behaviour of the dog. Chicago, University of Chicago Press

SELBY, L. A., RHOADES, J. D., IRVIN, J. A., CAREY, G. E. & WADE, R. G. (1980) Values and limitations of pet ownership. Journal Of The American Veterinary Medical Association 176, 1274-1276

SERPELL, J. (1991) Beneficial effects of pet ownership on some aspects of human health and behavior. Journal Of The Royal Society Of Medicine 84, 717-720

SERPELL, J. (1995) Introduction. In The domestic dog: its evolution, behaviour and interactions with people. Ed J. SERPELL. Cambridge, Cambridge University Press. pp 1-4

SERPELL, J. A. (1996) Evidence for an association between pet behavior and owner attachment levels. Applied Animal Behaviour Science 47, 49-60

SHARMA, S. (1996) Cluster Analysis. In Applied Multivariate Techniques, John Wiled and Sons Inc. pp 185-237

SHEWELL, P. C. & NANCARROW, J. D. (1991) Dogs that bite. British Medical Journal 303, 1512-1513

SHIRLEY, M. D. F. & RUSHTON, S. P. (2005a) The impacts of network topology on disease spread. Ecological Complexity 2, 287-299

SHIRLEY, M. D. F. & RUSHTON, S. P. (2005b) Where diseases and networks collide: lessons to be learnt from a study of the 2001 foot-and-mouth disease epidemic. Epidemiology And Infection 133, 1023-1032

SIEGAL, S. & CASTELLAN JR, N. (1988) Ordered variables and the Gamma Statisic *G*. In Nonparametric statistics for the behavioural sciences. Ed J. D. ANKER, McGraw-Hill Book Co. pp 291-298

SIEGEL, J. M., ANGULO, F. J., DETELS, R., WESCH, J. & MULLEN, A. (1999) AIDS diagnosis and depression in the Multicenter AIDS Cohort Study: the ameliorating impact of pet ownership. Aids Care-Psychological And Socio-Medical Aspects Of Aids/Hiv 11, 157-170

SLOVIC, P. (2004) Introduction and overview. In The Perception of Risk. Ed R. A. LOFSTEDT. London, Earthscan Publications Ltd

SMITH, S. L. (1983) Interactions between pet dog and family members: An ethological study. In New perspectives on our lives with companion animals. Ed A. H. KATCHER, BECK A.M. Philadelphia, University of Pennsylvania Press. pp 29-36

SOC (2000) Standard Occupational Classification. http://www.statistics.gov.uk/nsbase/methods_quality/ns_sec/soc2000.asp#vol1Access, 2000

TAM, C. C., O'BRIEN, S. J., ADAK, G. K., MEAKINS, S. M. & FROST, J. A. (2003) Campylobacter coli - an important foodborne pathogen. Journal of Infection 47, 28-32

TAN, J. S. (1997) Human zoonotic infections transmitted by dogs and cats. Archives of Internal Medicine 157, 1933-1943

TECLAW, R., MENDLEIN, J., GARBE, P. & MARIOLIS, P. (1992) Characteristics of pet populations and households in the Purdue-Comparative-Oncology-Program Catchment-Area, 1988. Journal Of The American Veterinary Medical Association 201, 1725-1729

TENKATE, T. D. & STAFFORD, R. J. (2001) Risk factors for campylobacter infection in infants and young children: a matched case-control study. Epidemiology and Infection. 127, 399-4040

TENNANT, B. J., GASKELL, R. M. & GASKELL, C. J. (1994) Studies on the survival of canine coronavirus under different environmental conditions. Veterinary Microbiology 42, 255-259

TORRE, E. & TELLO, M. (1993) Factors influencing fecal shedding of Campylobacter jejuni in dogs without diarrhea. American Journal of Veterinary Research 54, 260-262

TOWER, R. B. & NOKOTA, M. (2006) Pet companionship and depression: results from a United States Internet sample. Anthrozoos 19, 50-64

TROUTMAN, C. M. (1988) Veterinary services market for companion animals. Journal Of The American Veterinary Medical Association 193, 920-922, 1056-1058, 1217-1219

TSAI, H. J., HUANG, H. C., LIN, C. M., LIEN, Y. Y. & CHOU, C. H. (2007) Salmonellae and campylobacters in household and stray dogs in northern taiwan. Veterinary Research Communications 31, 931-939

WALTNER-TOEWS, D. (1993) Zoonotic disease concerns in Animal-Assisted Therapy and Animal Visitation Programs. Canadian Veterinary Journal-Revue Veterinaire Canadienne 34, 549-551

WANG, G., CLARK, C. G., TAYLOR, T. M., PUCKNELL, C., BARTON, C., PRICE, L., WOODWARD, D. L. & RODGERS, F. G. (2002) Colony multiplex PCR assay for identification and differentiation of Campylobacter jejuni, C. coli, C. lari, C. upsaliensis, and C. fetus subsp. fetus. J Clin Microbiol 40, 4744-4747

WATTS, D. J. & STROGATZ, S. H. (1998) Collective dynamics of 'small-world' networks. Nature 393, 440-442

WEBER, A., WACHOWITZ, R., WEIGL, U. & SCHAFER-SCHMIDT, R. (1995) Occurence of Salmonella in fecal samples of dogs and cats in northern Bavaria from 1975 to 1994. Barl Munch Tierarztl Wochenschr 108, 401-404

WEBLEY, P. & SIVITER, C. (2000) Why do some owners allow their dogs to foul the pavement? The social psychology of a minor rule infraction. Journal Of Applied Social Psychology 30, 1371-1380

WELLS, D. L. (2006) Factors influencing owners' reactions to their dogs' fouling. Environment and Behavior 38, 707-714

WIELAND, B., REGULA, G., DANUSER, J., WITTWER, M., BURNENS, A. P., WASSENAAR, T. M. & STARK, K. D. C. (2005) Campylobacter spp. in dogs and cats in Switzerland: Risk factor analysis and molecular characterization with AFLP. Journal of Veterinary Medicine Series B-Infectious Diseases and Veterinary Public Health 52, 183-189

WISE, J. K. & KUSHMAN, J. E. (1984) Pet ownership by life group. Journal Of The American Veterinary Medical Association 185, 687-690

WISE, J. K. & YANG, J. J. (1992) Veterinary Service Market For Companion Animals, 1992 .1. Companion Animal Ownership And Demographics. Journal Of The American Veterinary Medical Association 201, 990-992

WOLFE, A. & WRIGHT, I. P. (2003) Human toxocariasis and direct contact with dogs. Veterinary Record 152, 419-422

WONG, S. K., FEINSTEIN, L. H. & HEIDMANN, P. (1999) Healthy pets, healthy people. Journal Of The American Veterinary Medical Association 215, 335-338

WORKMAN, S. N., MATHISON, G. E. & LAVOIE, M. C. (2005) Pet dogs and chicken meat as reservoirs of Campylobacter spp. in Barbados. Journal of Clinical Microbiology 43, 2642-2650

GENERAL APPENDIX

DOGS IN THE COMMUNITY SURVEY

QUESTIONNAIRE AND ANSWERS

To gather the information required for Chapters Two to Five, data were collected from people in a community using a questionnaire.

A combination of face-to-face, short door-step interview, and further self-administered questionnaire was chosen for this study. The decision to use mainly closed, pre-defined questions was based partly on the decision to use an automated content capture software, Verity TELE*form*, in the design and data entry of the survey. After design in the program and distribution of the questionnaire, completed forms can be scanned and verified and committed straight to a chosen database such as Microsoft Access.

The questionnaire had a number of sections:

- Section A was a cross-sectional study of the households investigated, outlining some factors that may contribute to why some people own dogs and others do not. This section took approximately 2 minutes and was a face-to-face interview on the doorstep.
- Section B was for households that own dogs. Basic details of each dog were collected as above; this section took approx 1 minute.
- A longer, detailed questionnaire (Sections C and D) was left with households that own dogs to be filled in and returned in a pre-paid envelope. This formed a cross-sectional study of dog ownership, identifying types and frequency of dog-human contact in the household and possible contacts with visitors and strangers. It also investigated in detail the frequency and locations of dog walks, and behaviour of dogs when meeting people and dogs, in order to map the contact networks that exist between pet dogs in the area. The questionnaire also collected information on the dog's health, diet and toileting habits. Section C consisted of questions specific to each dog so was repeated for each dog in the household. Section D consisted of generic questions that only needed answering once for all dogs in the household. Sections C and D took approximately 15 minutes to complete for one dog, longer if extra dogs were present.

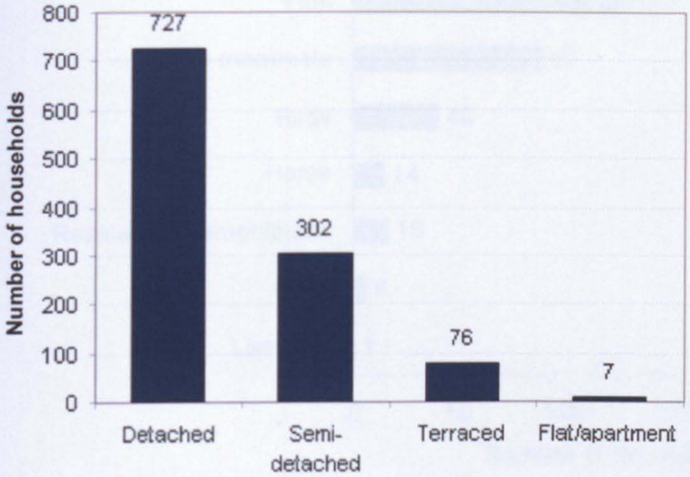
The questionnaire was designed with input from veterinarians, professional dog behaviourists, dog owners and non-dog owners. After extensive scrutiny the questionnaire underwent preliminary piloting on volunteers in the veterinary school, including vets, dog trainers, first-time dog owners, experienced dog owners and non-dog owners.

Once the questionnaire had been designed it needed to be piloted on a sample population. A group of 97 houses was chosen for this purpose in a nearby village, and appropriate changes made.

Informational leaflets were distributed through the area one week before the study. The questionnaire was left with a pre-paid, first class, printed addressed envelope. To provide incentives, a local boarding kennels and a pet food manufacturer associated with the University were approached and offered to provide discount vouchers, to be sent out to households on receipt of their completed forms. A reminder postcard was designed to be put through the door a week later for those who had still not returned the questionnaire, and a second questionnaire was sent after a month if not returned.

Section A

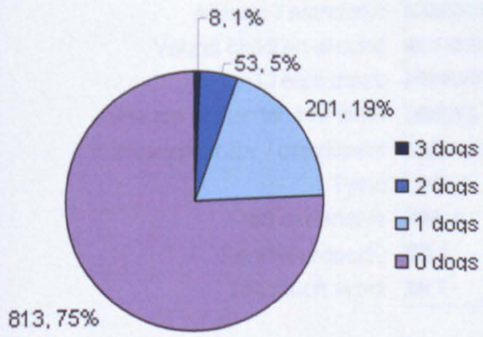
House type



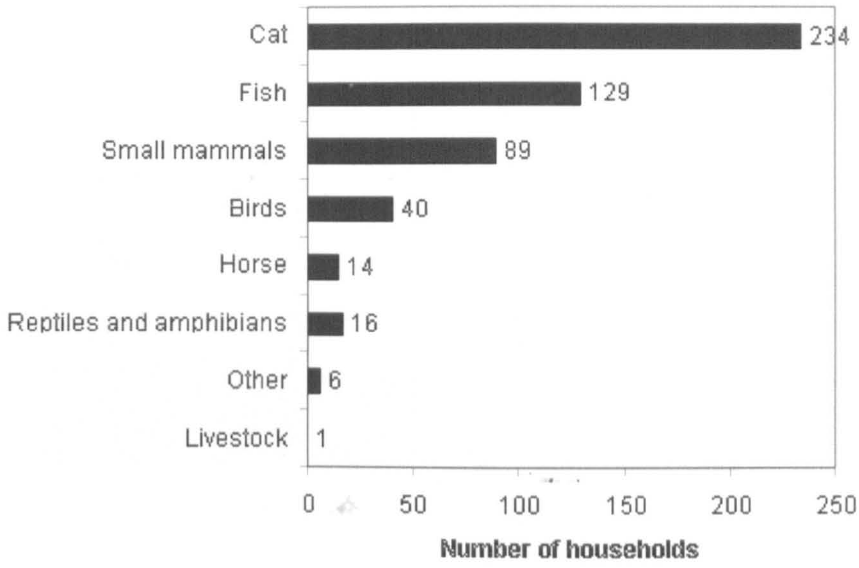
Street type
52% Through road (576)
48% Cul-de-sac (536)

1. a) Are there any pets in the household?
52% Yes (560)
48% No (511)

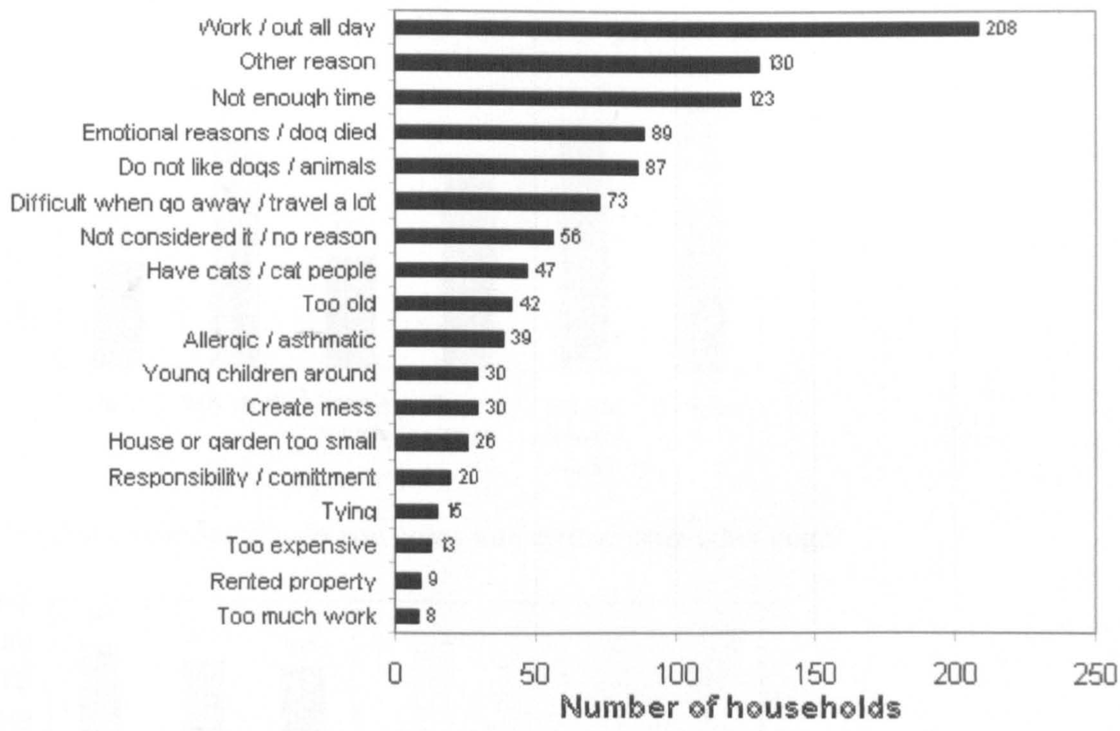
b) How many dogs are there in the household (sleep most nights of the week)?



c) Are there any other animals owned by the household?

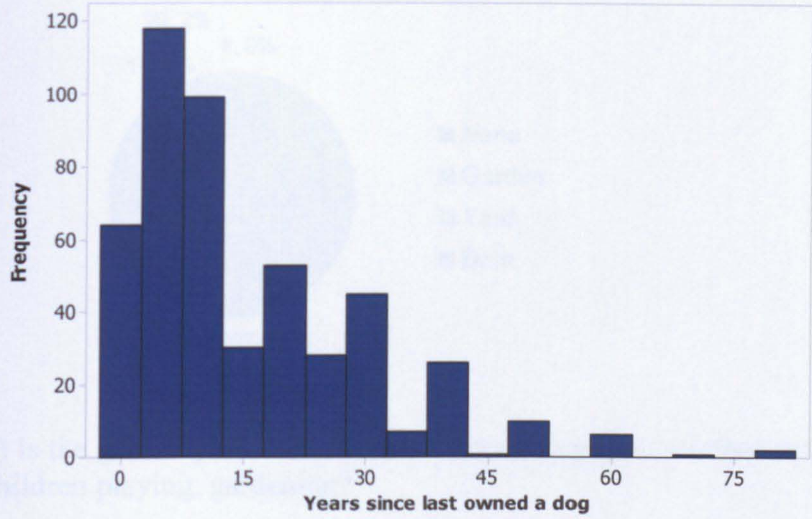


2. a) Are there any particular reasons why you do not own a dog at this time?

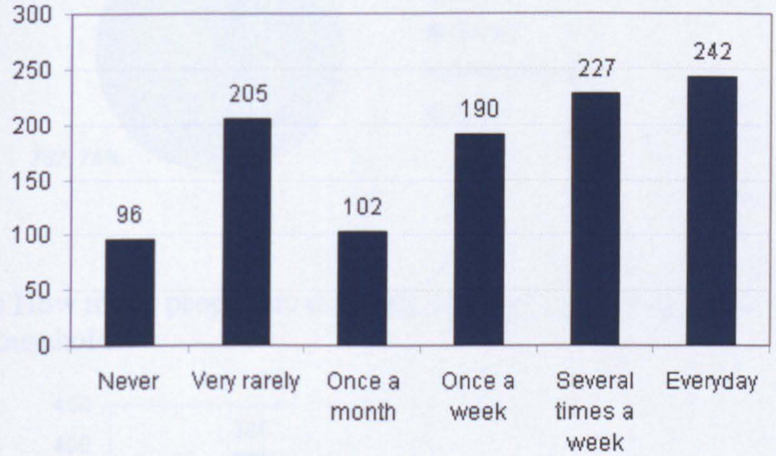


b) Have you owned dogs in the past?
62% Yes (501)
38% No (304)

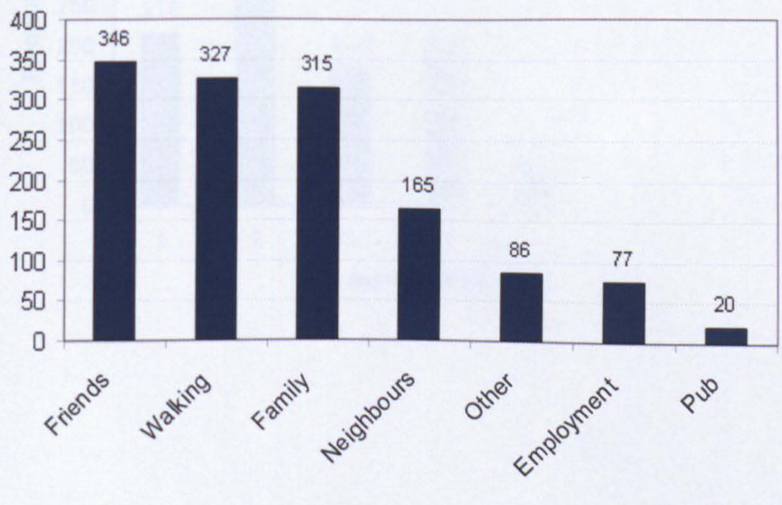
c) How long ago did you own your last dog?



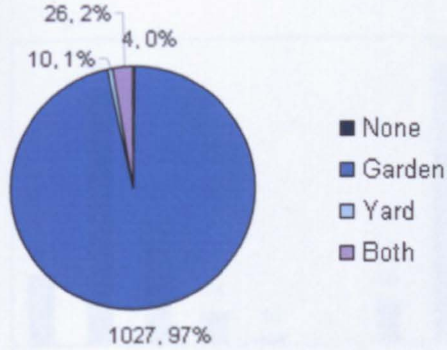
3. a) How often do you come into physical contact (e.g. touch, petting, dog jumping up) with other dogs?



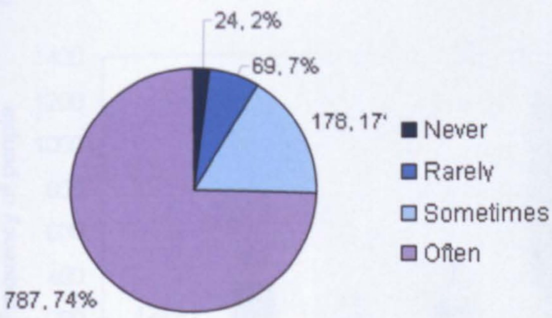
b) In what circumstances do you come into contact with other dogs?



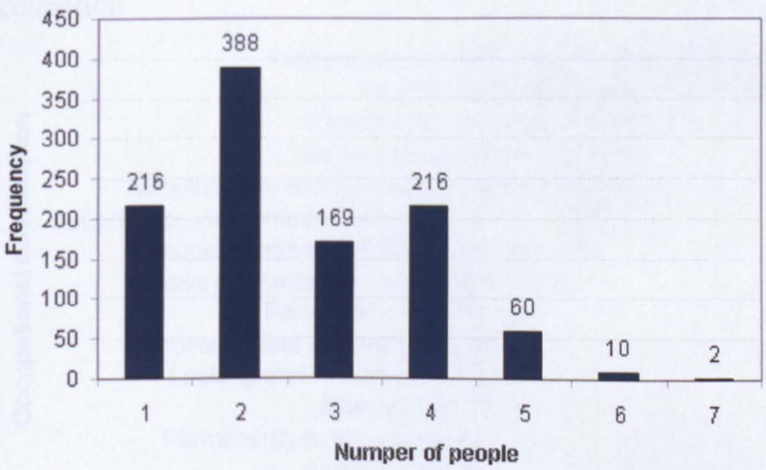
4. a) Does the household have a garden or yard?



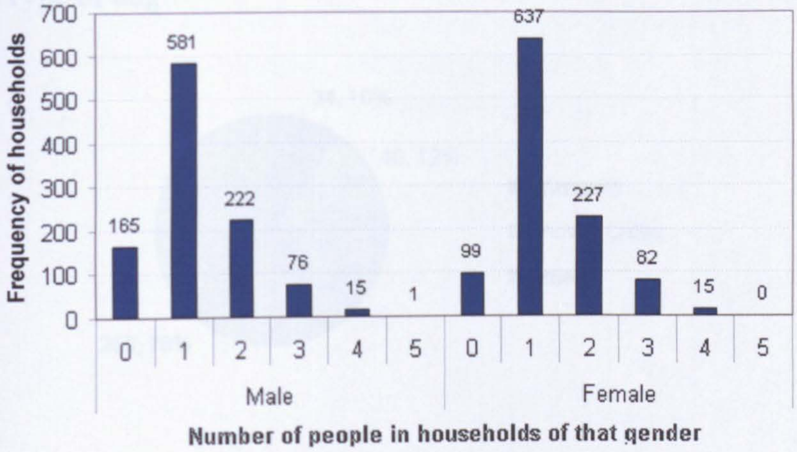
b) Is the garden/yard used for recreational purposes, weather permitting, e.g. eating, children playing, gardening?



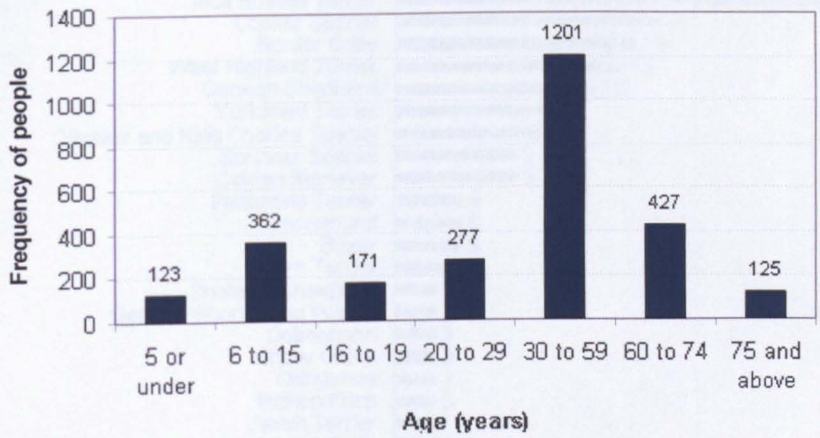
5) How many people are currently resident (as in sleep most nights of the week) in the household?



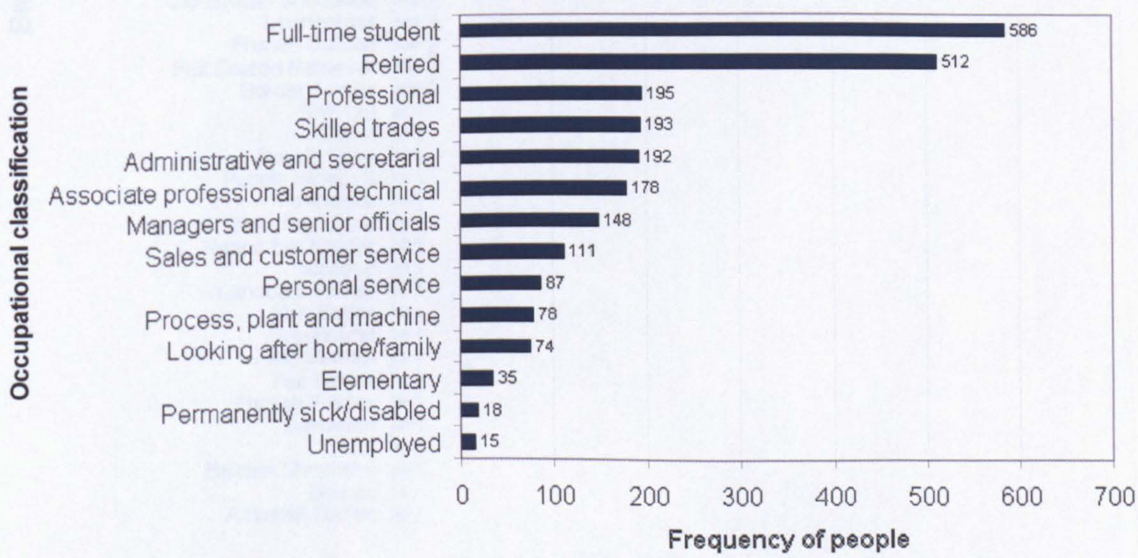
b)
Gender



Age

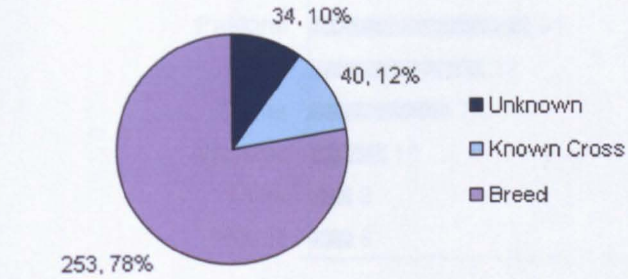


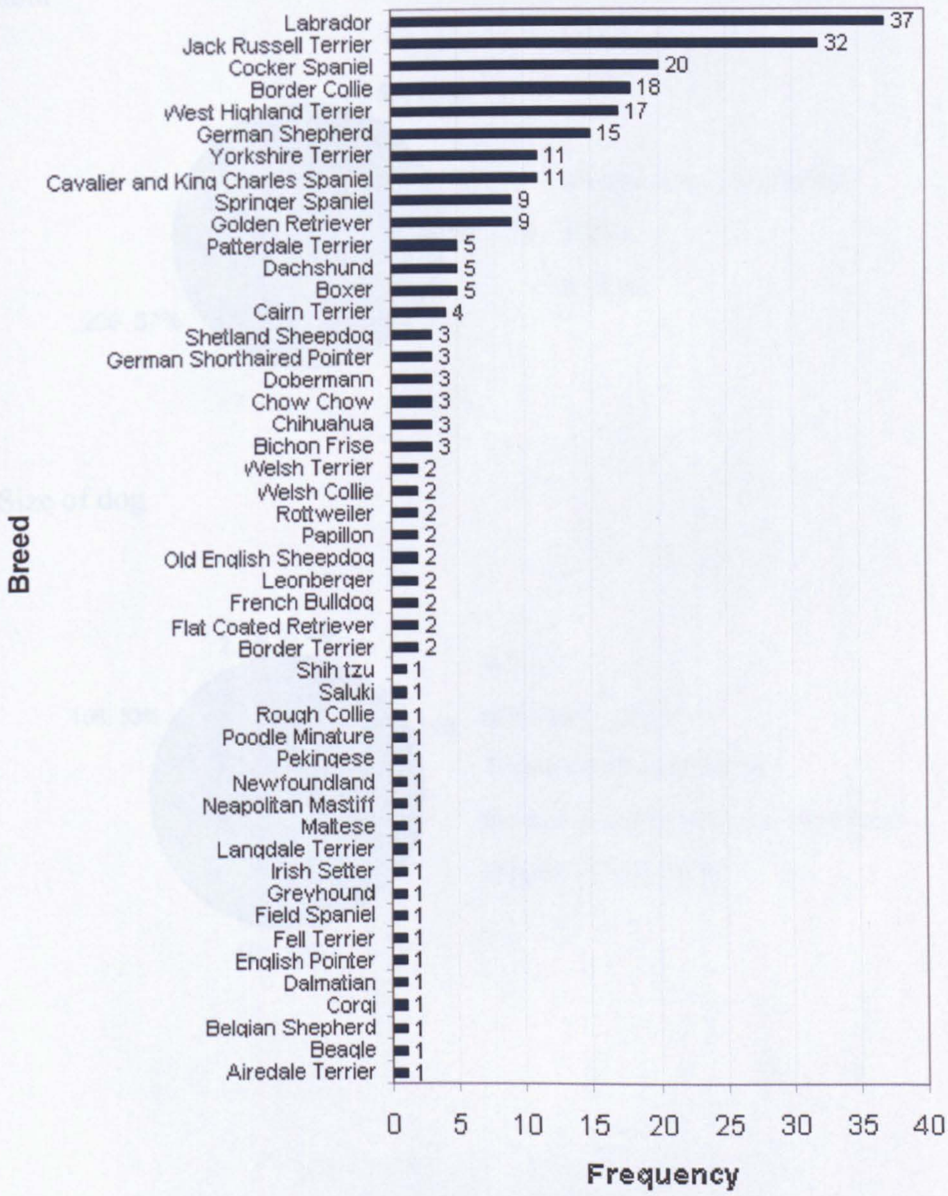
Occupation

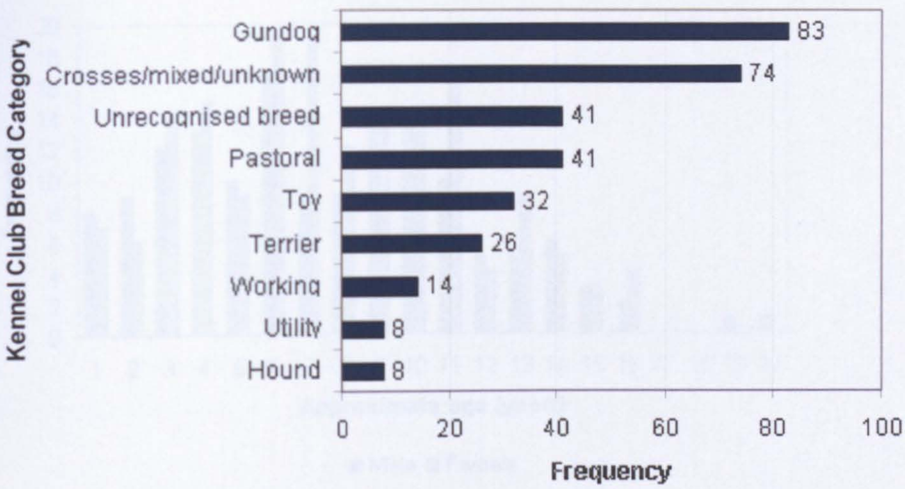


Section B

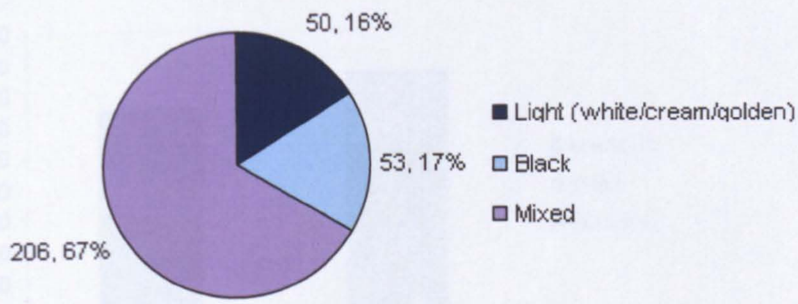
1. Type of dog



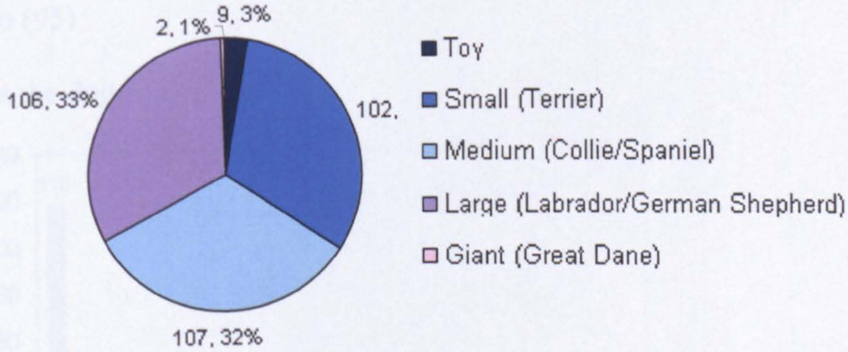




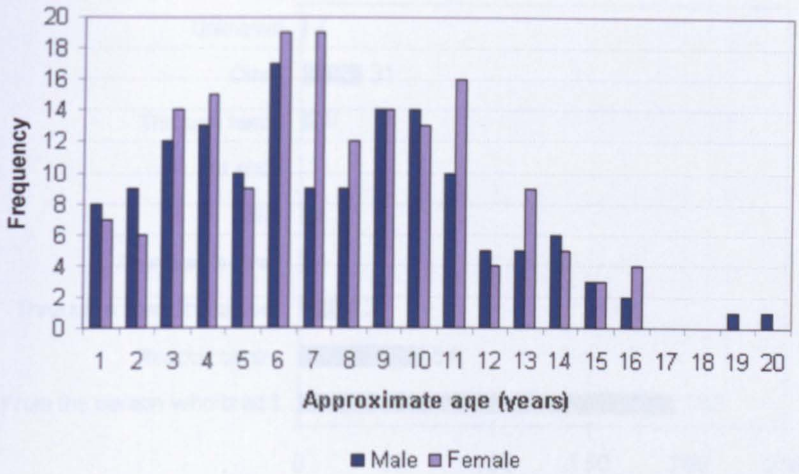
Colour



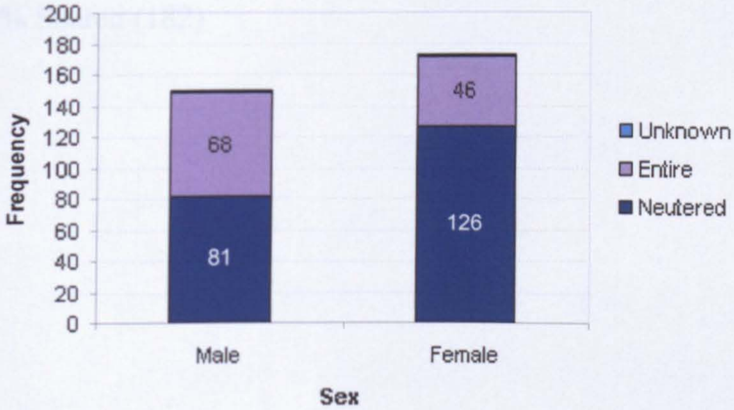
2. Size of dog



3. Age of dog

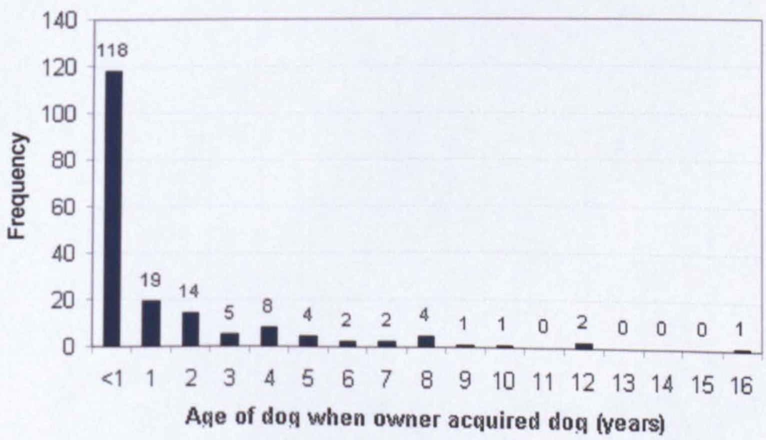


4. Sex of dog
5. Is the dog neutered?

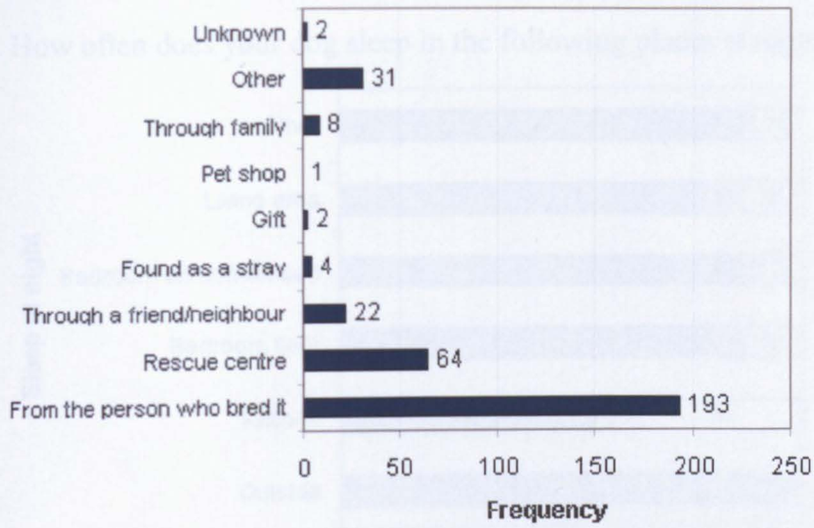


6. Have you owned the dog all of its life (since it was a puppy at 12 weeks?)
71% Yes (229)
29% No (95)

Age got the dog



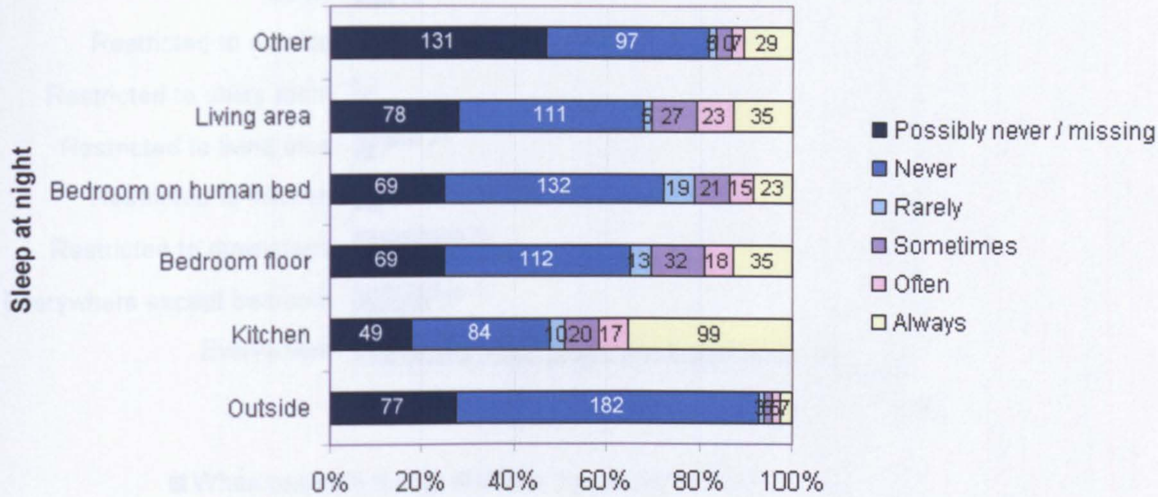
7. Where did you get the dog?



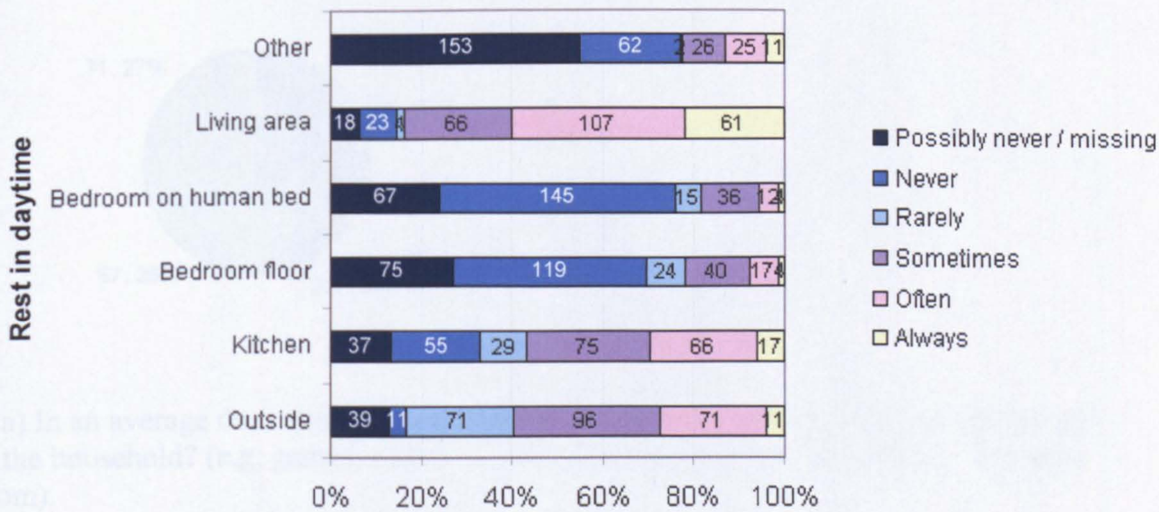
8. Who carries out dog duties (feeding, exercising) for this dog?
44% One main person (144)
56% Shared (182)

Section C

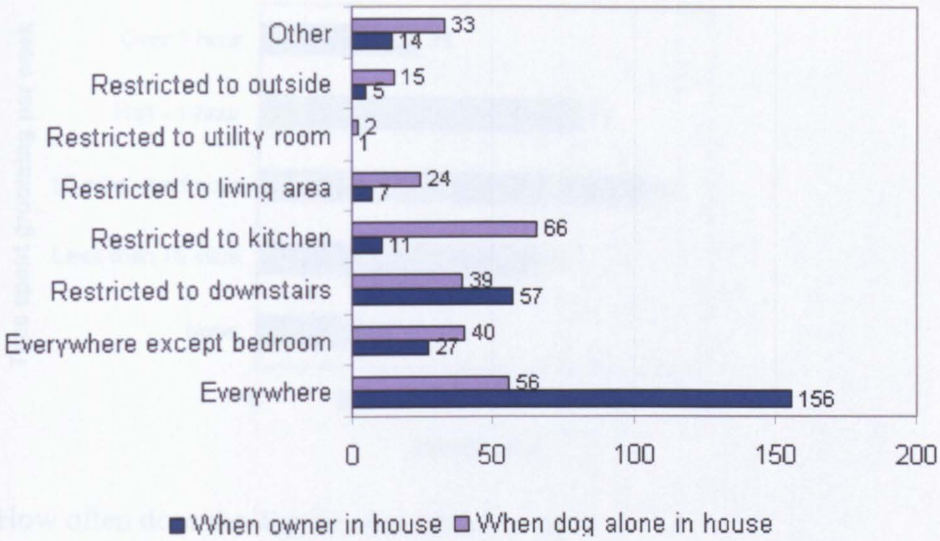
1. How often does your dog sleep in the following places at night?



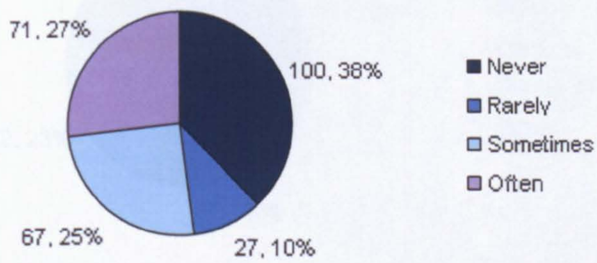
2. How often does the dog rest in the following locations during the day when you are in the house?



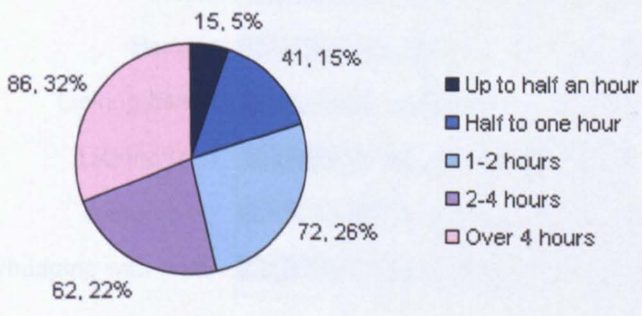
3. When you are in the house, where in the house does the dog have access?
4. When you are not in the house, where in the house does the dog have access?



5. Does the dog lie on furniture?

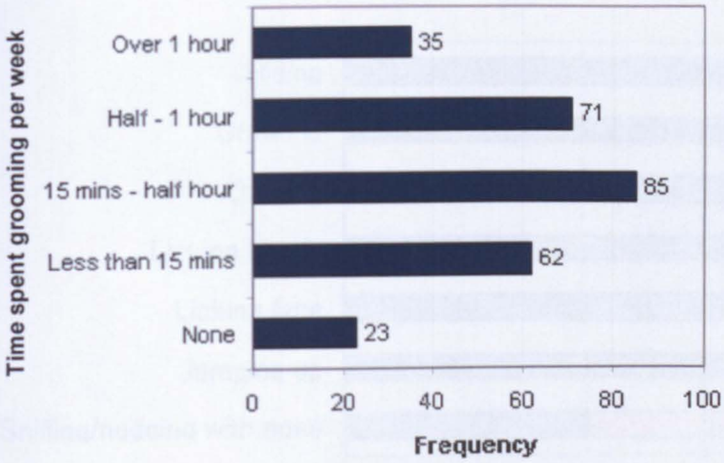


6. a) In an average day, estimate how much time the dog spends interacting with people in the household? (e.g. games, cuddles, training, grooming, not just resting in the same room).

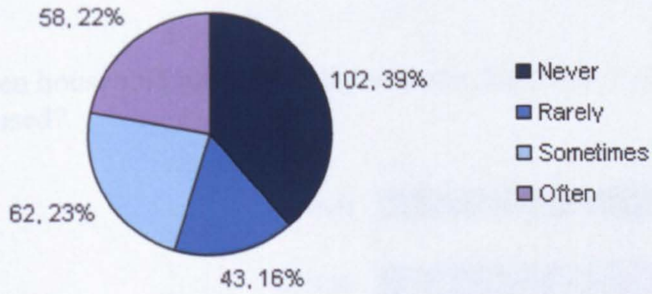


b) Is this interaction all with one person or with a variety of persons?
17% One person (42)
83% Variety of persons (205)

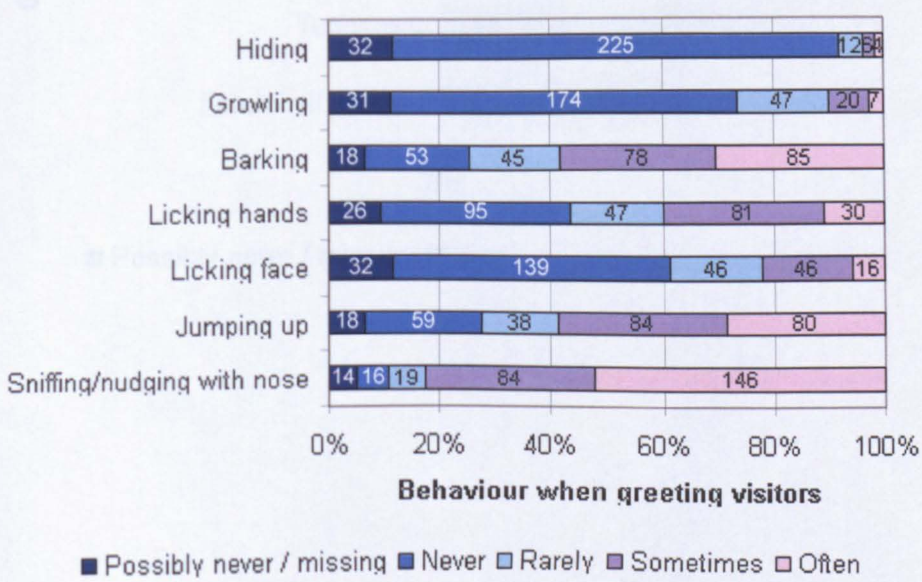
7. In an average week, how much time in total do you spend grooming your dog? (e.g. brushing, bathing).



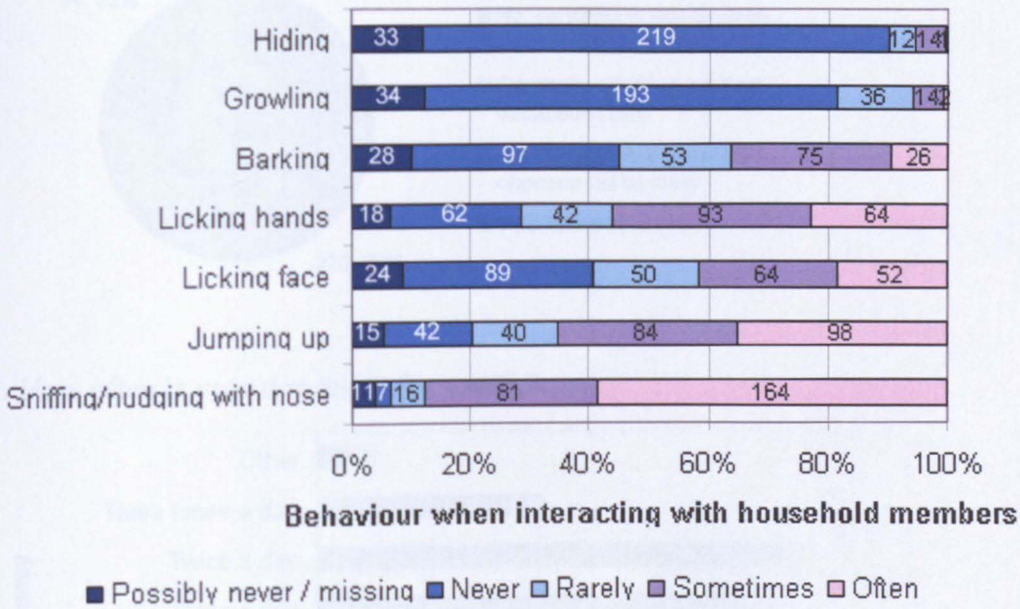
8. How often does the dog lie on a person's lap?



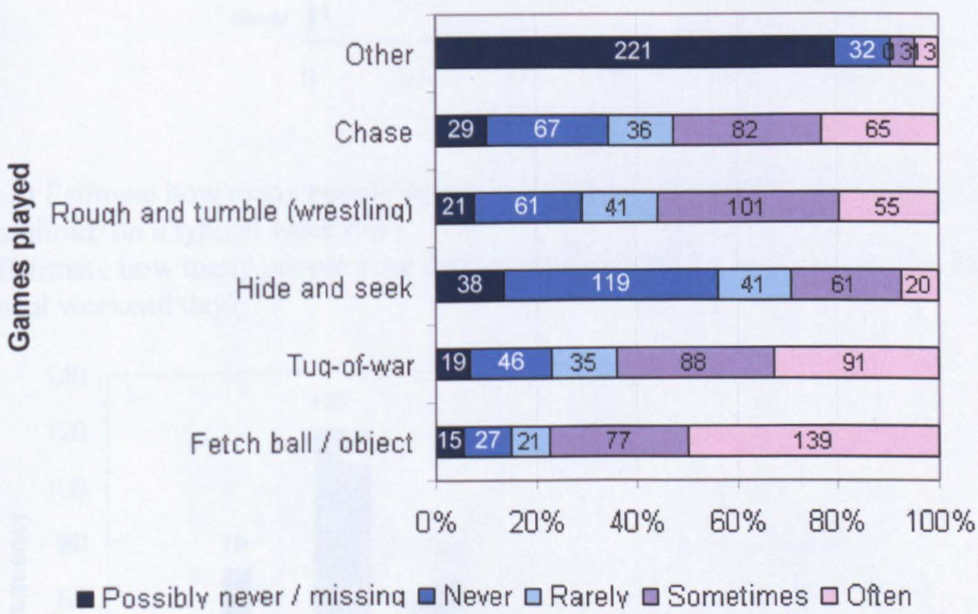
9. When your dog is greeting visitors, how often are the following types of behaviour seen?



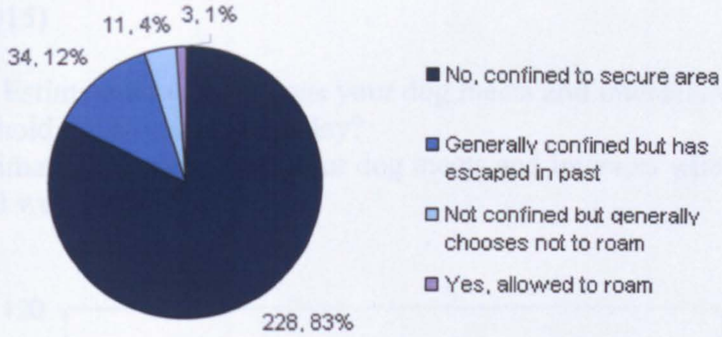
10. When your dog is interacting with household members, how often are the following types of behaviour seen?



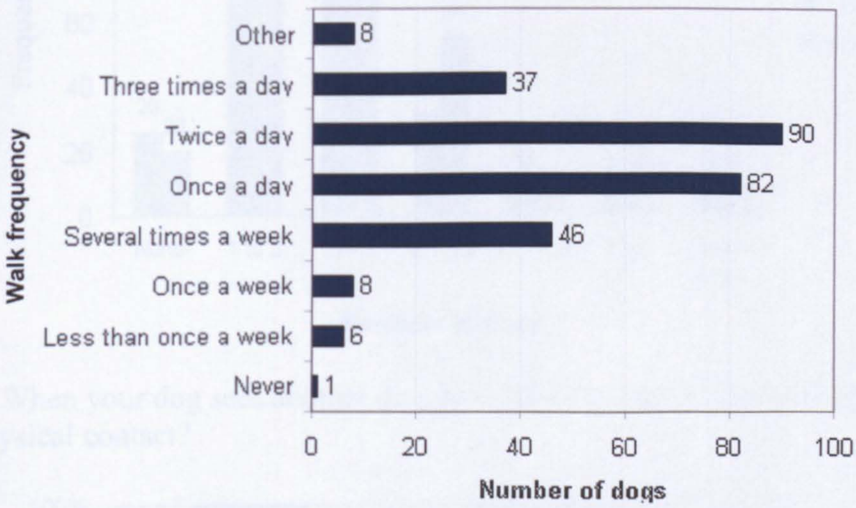
11. When household members play with the dog, how often are the following types of games used?



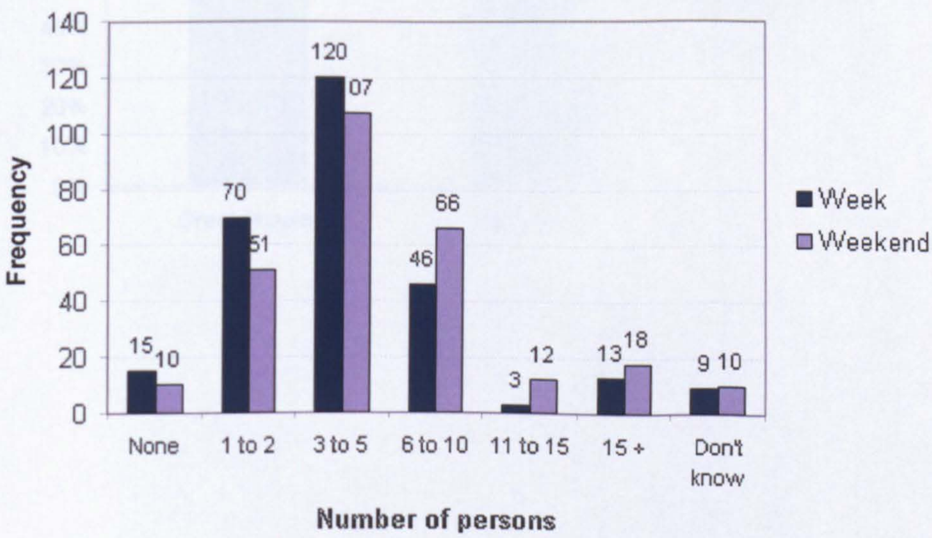
12. Does the dog ever roam unattended away from the premises?



13. How often is your dog taken for a walk?

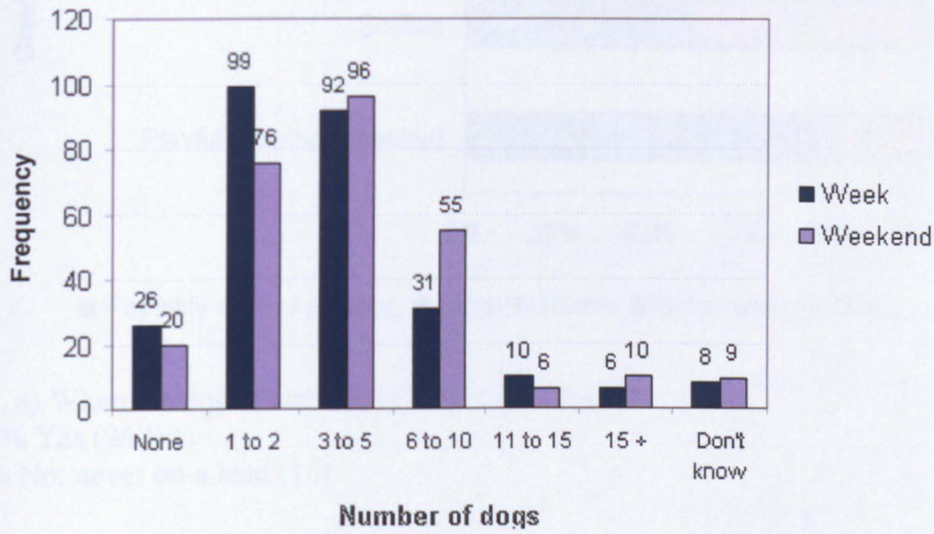


14. a) Estimate how many people your dog meets and interacts with, outside the household, on a typical week day?
b) Estimate how many people your dog meets and interacts with, outside the house, on a typical weekend day?



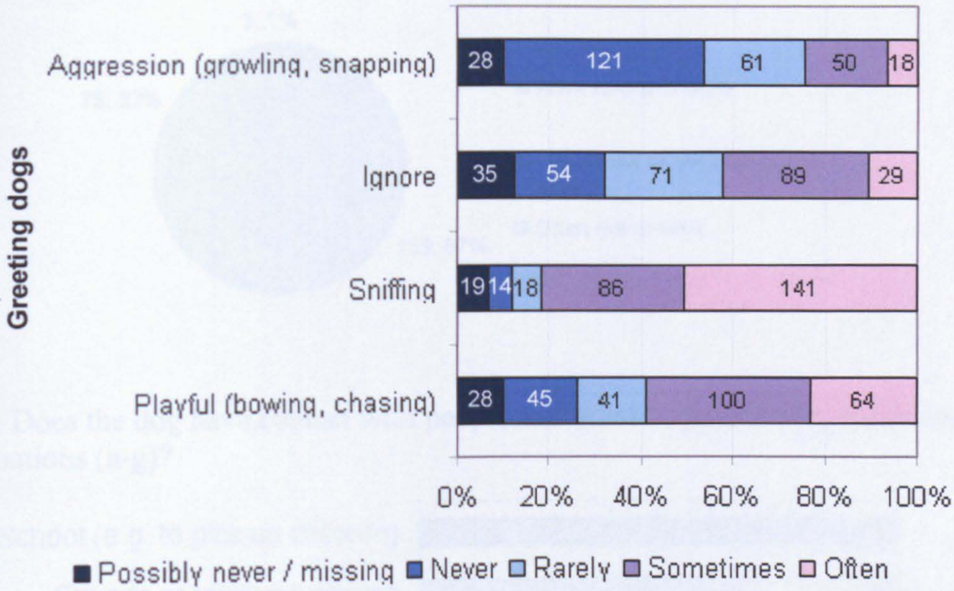
c) When your dog sees a person, how likely is the dog to greet them and make physical contact?
(see Q15)

15. a) Estimate how many dogs your dog meets and interacts with, outside the household, on a typical week day?
b) Estimate how many dogs your dog meets and interacts with, outside the house, on a typical weekend day?



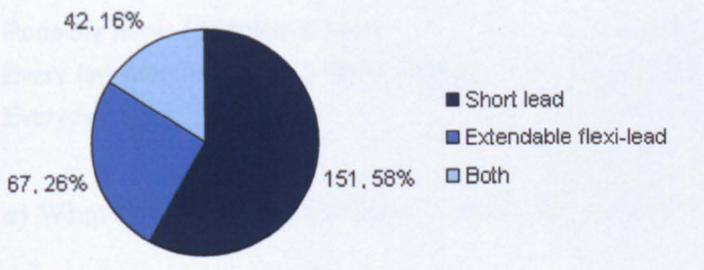
c) When your dog sees another dog, how likely is your dog to greet them and make physical contact?

16. For the following behaviours, please indicate how much the dog shows when interacting with other dogs on a walk.

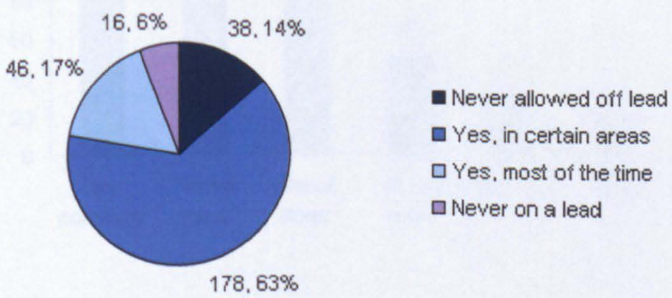


17. a) When the dog is walked, is it ever on a lead?
94% Yes (260)
6% No, never on a lead (16)

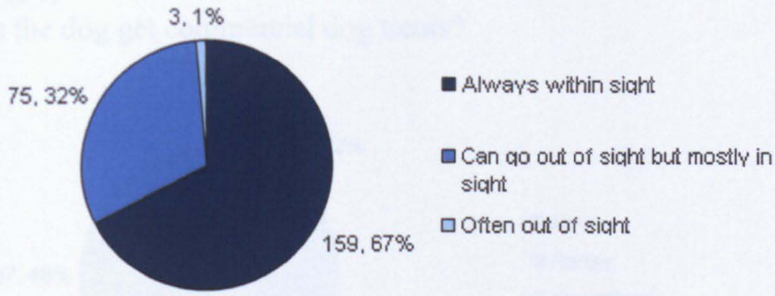
b) What type of lead is used for this dog?



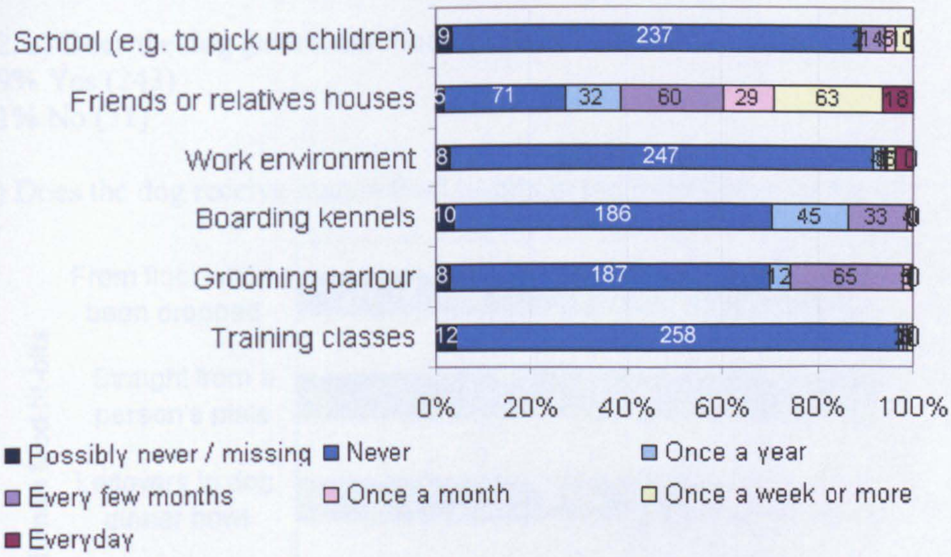
18. a) Is the dog ever allowed off lead?



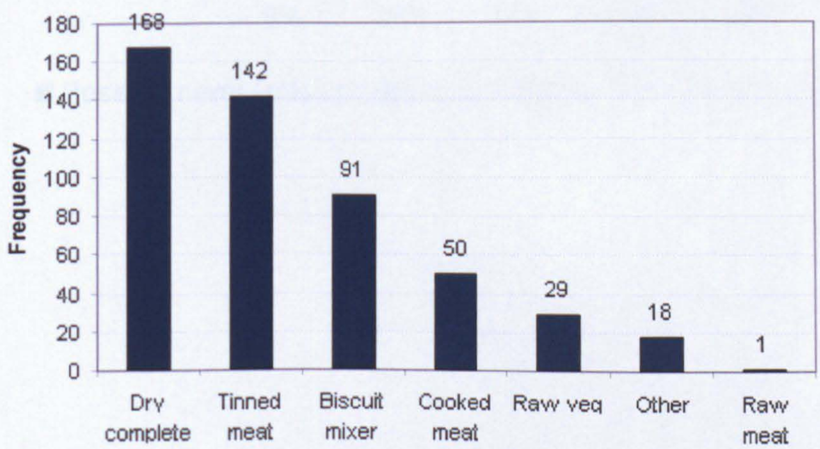
b) When the dog is off lead is it…



19. Does the dog have contact with people and other dogs in any of the following situations (a-g)?

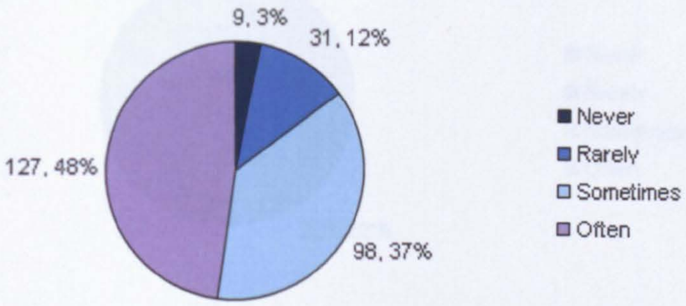


20. a) What type of food does the dog eat as the main diet?



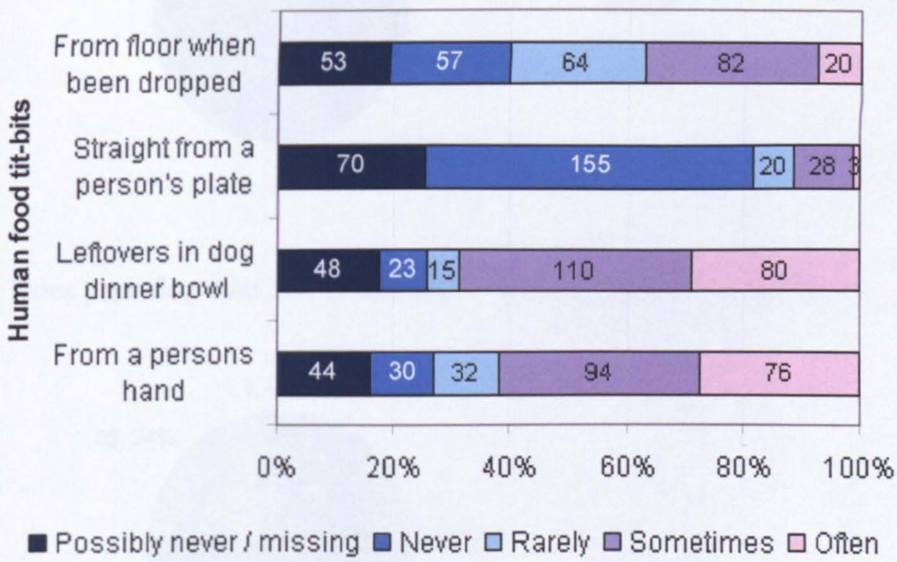
b) Is the dog fed in the kitchen?
79% Yes (201)
21% No (54)

21. Does the dog get commercial dog treats?

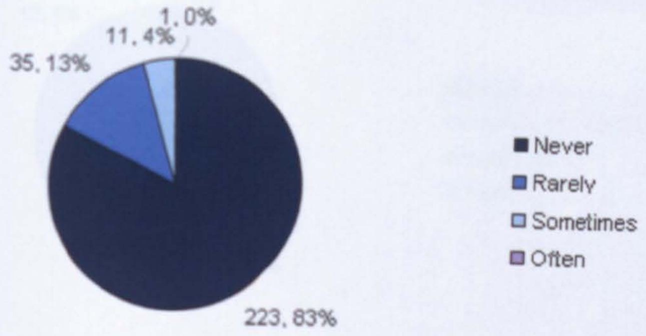


22. a) Does the dog get human food tit-bits?
89% Yes (243)
11% No (31)

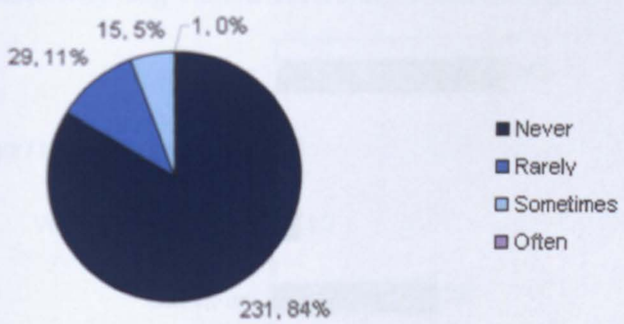
b) Does the dog receive human food tit-bits in the following situations?



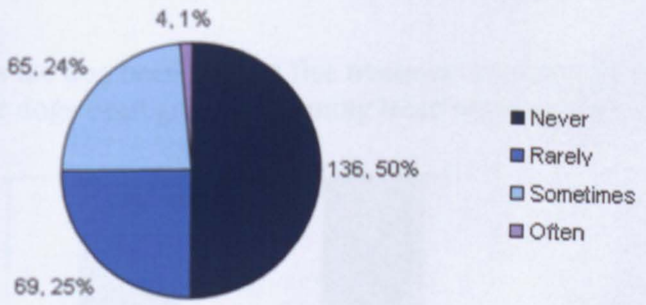
23. Do you ever feed your dog raw meat?



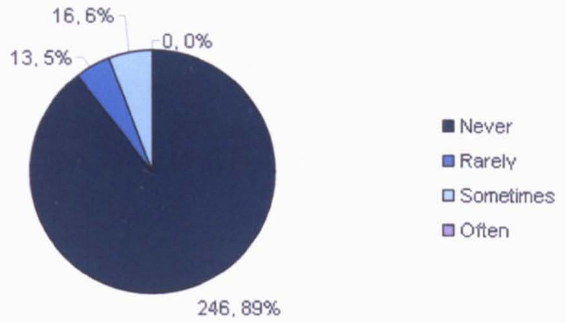
24. Does your dog ever find and eat raw carcasses, e.g. *dead bird or rabbit?*



25. Does your dog ever roll in carcasses or faeces (animal droppings?)

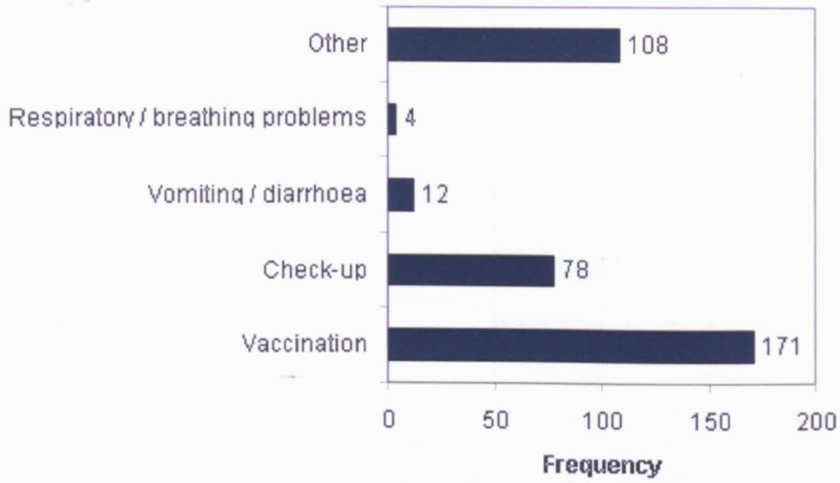


26. Does your dog ever find and eat dog faeces? (Its own or from another dog).

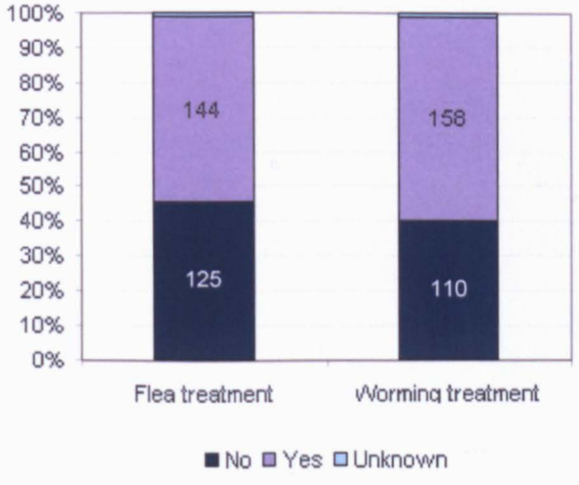


27. a) Has this dog been to a veterinary surgeon in the past year?
16% No (45)
84% Yes (230)

b) Please state why dog visited veterinary surgeon in past year?

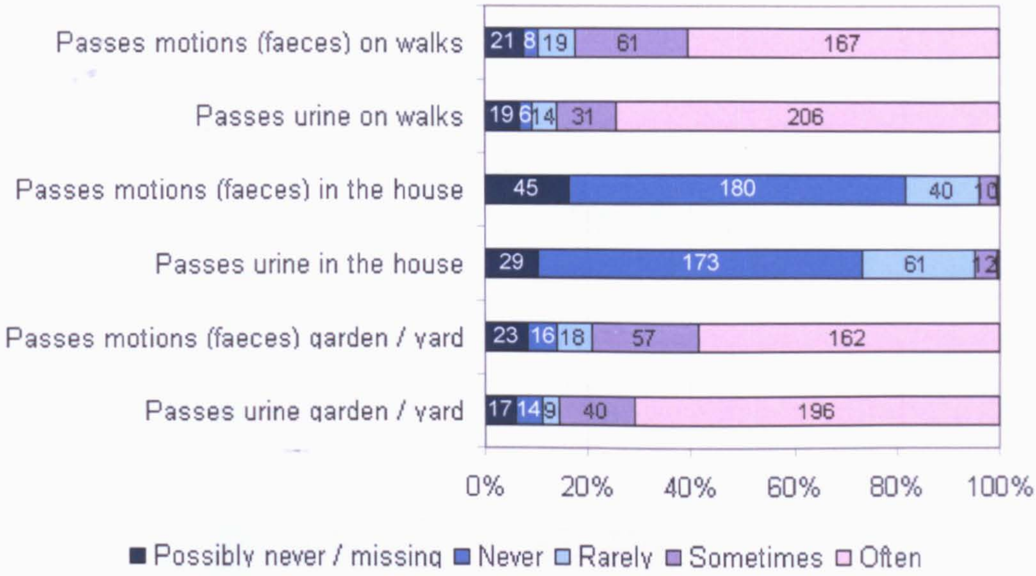


28. a) Has the dog been given a flea treatment recently (in the past three months)?
b) Has the dogs been given a worming treatment recently (in the past three months)?



c) Is the dog on any other medication?
86% No (233)
14% Yes (37)

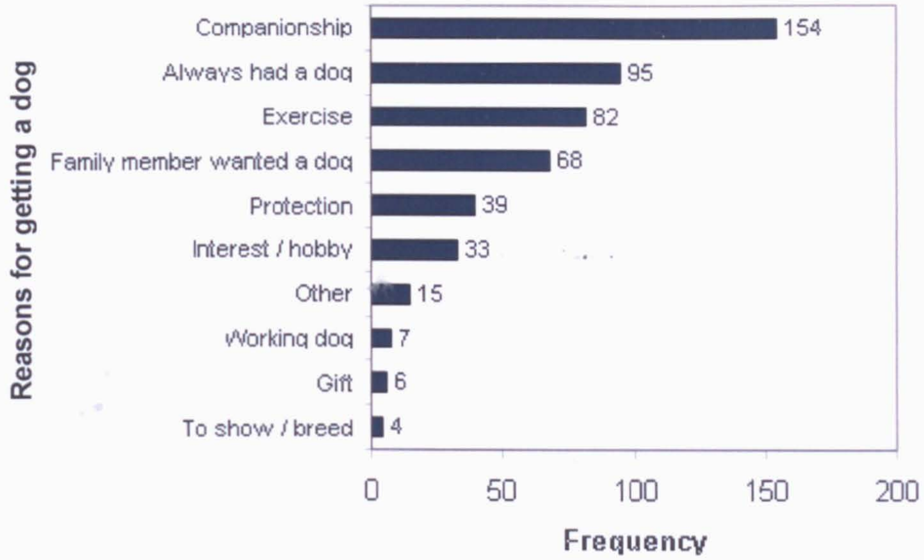
29. Please indicate how often your dog toilets in the following areas.



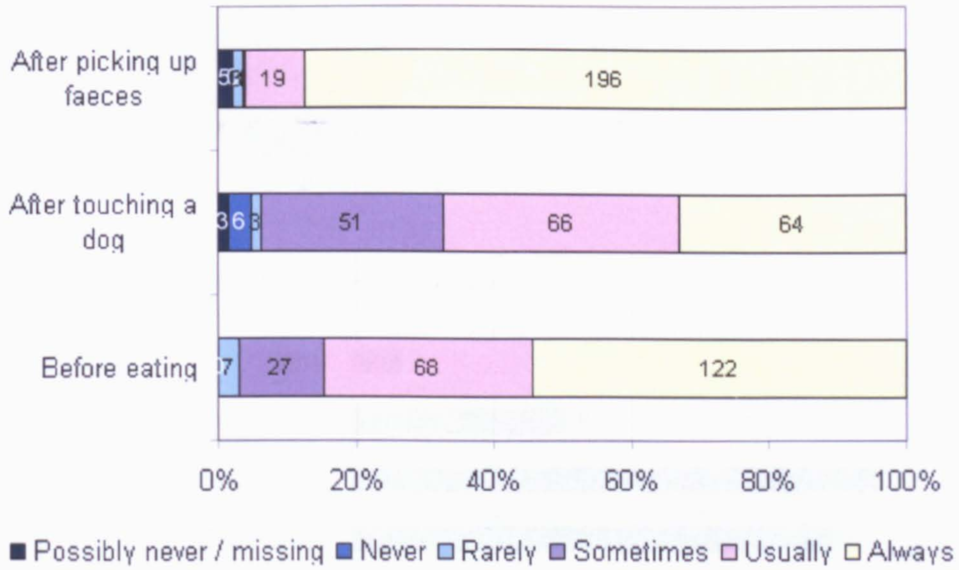
Section D

1. Have you owned dogs in the past?
85% Yes (184)
15% No – first dog (32)

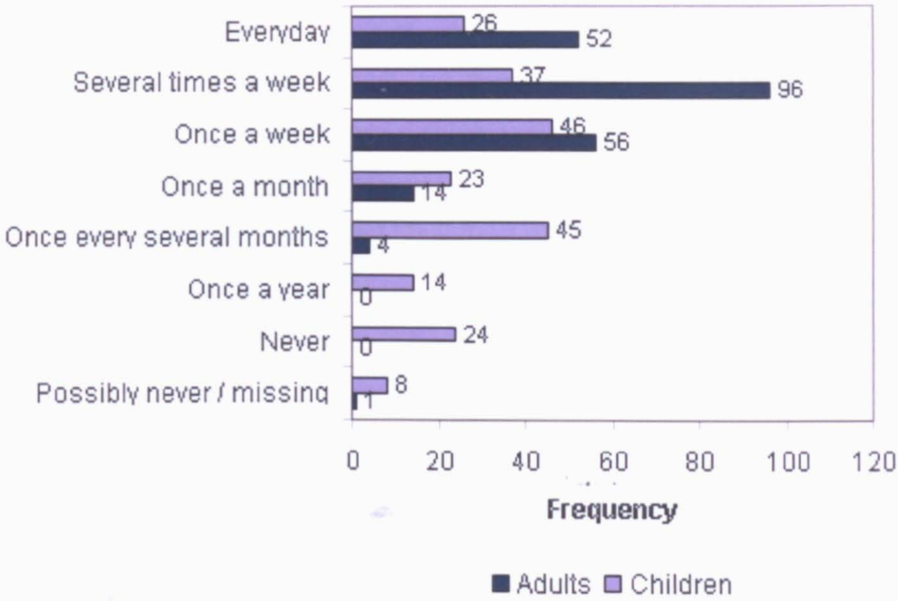
2. Why did you choose to get a dog?



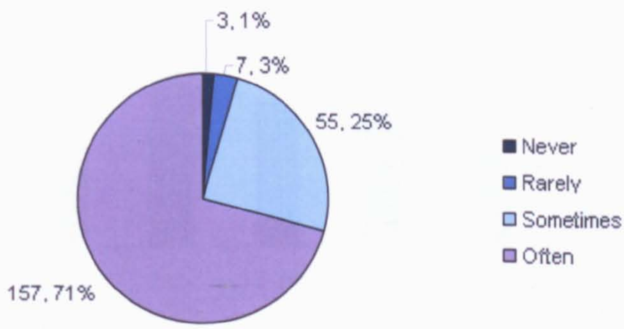
3. Do you wash your hands?



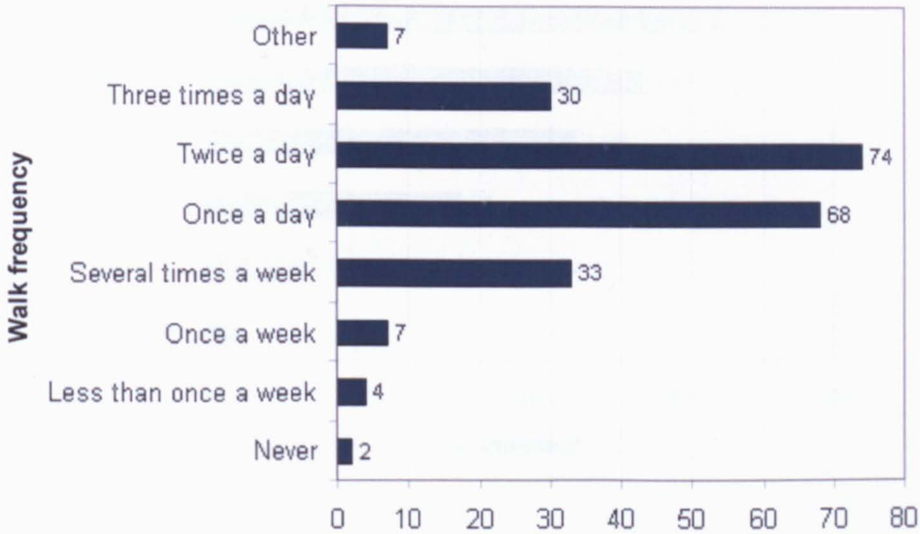
4. On average, how often to visitors come into the house?



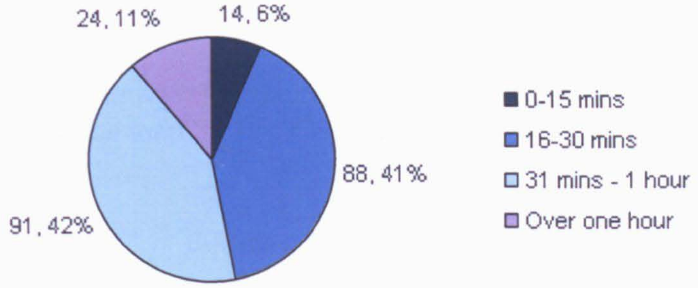
5. How often do household members interact or play with the dog(s) in the garden area?



6. How often is your dog taken for a walk?

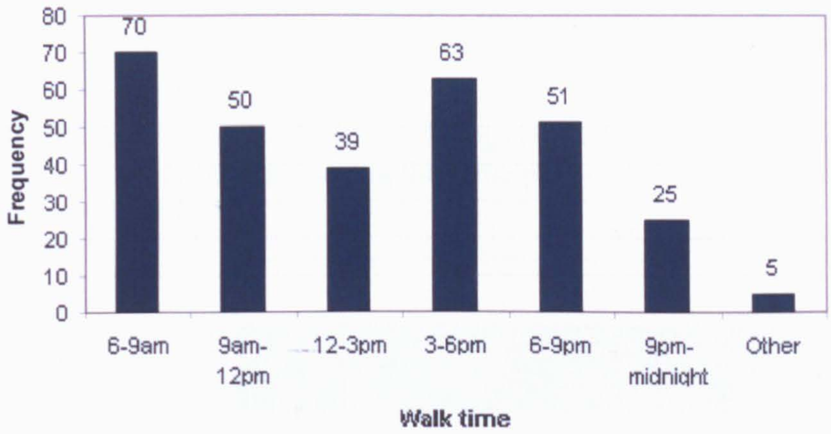


7. How long on average is each walk?

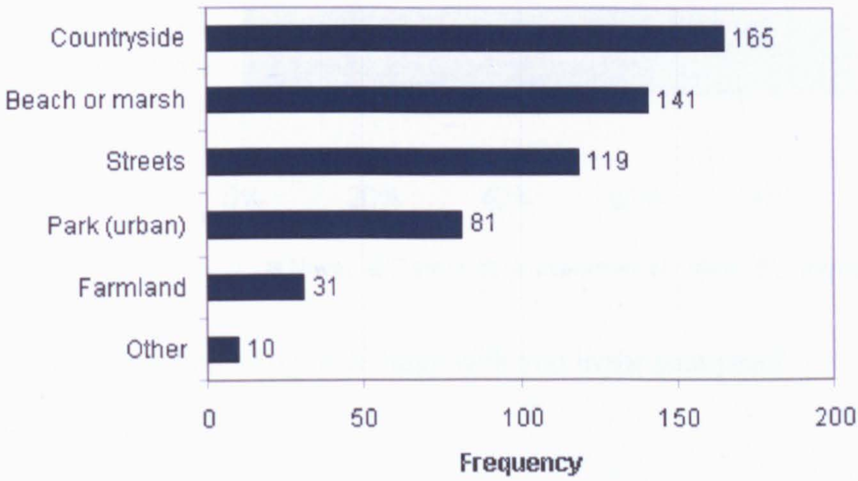


8. a) Are dog walks at a regular time of day?
53% Yes (114)
47% No (103)

b) Approximately what time of day is your dog walked?

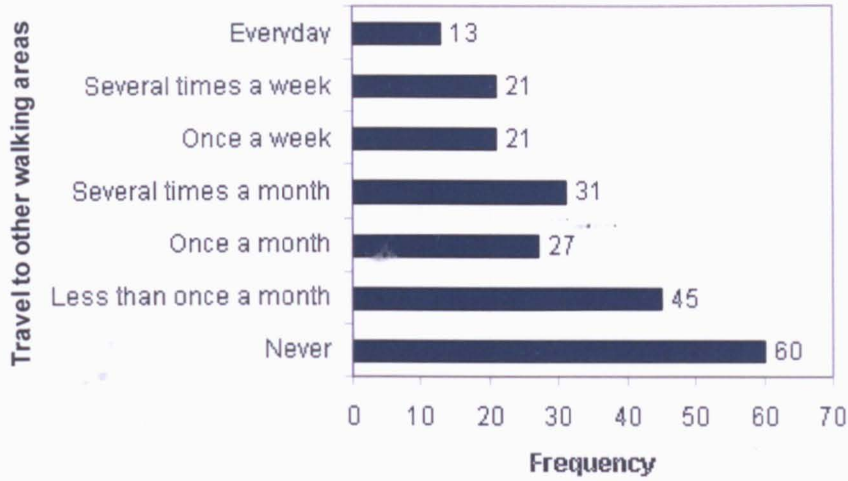


9. Which types of area do you often walk in?

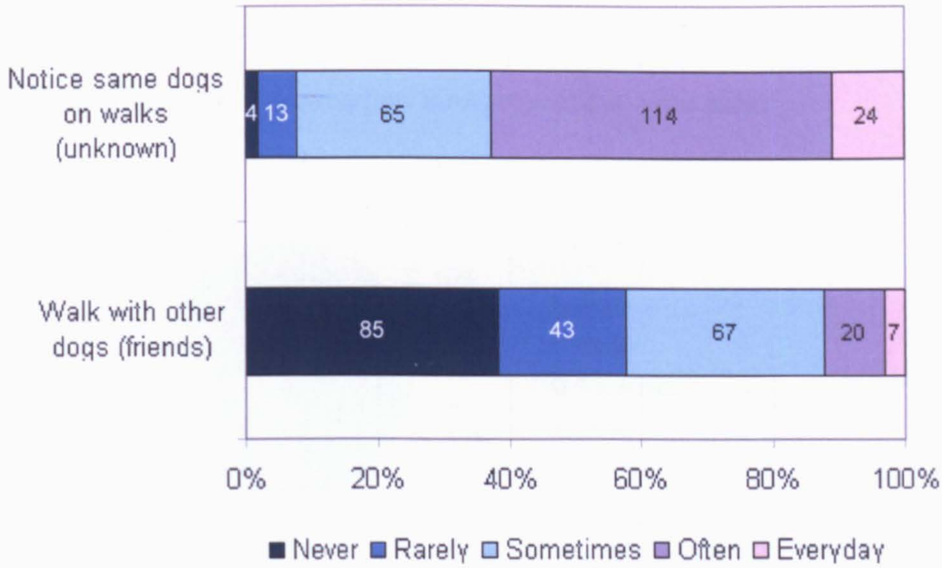


10. Do you regularly (mostly daily) walk in the same place?
69% Yes (150)
31% No, varies (66)
11. Map

12. Do you ever travel in the car or public transport to walk the dog (s) in areas not included on the map?



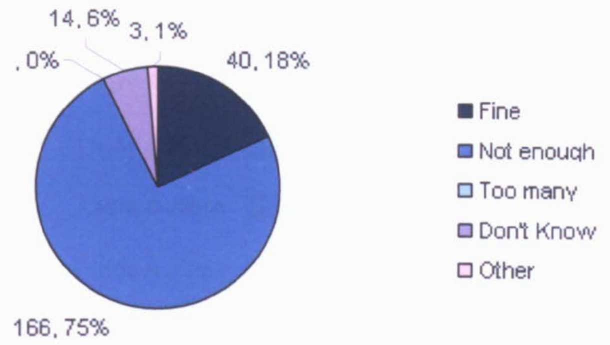
13. Is the dog ever walked with other dogs known to you (e.g. in a group of friends)?
14. Have you ever noticed seeing the same people and their dogs (otherwise unknown to you) on your walks?



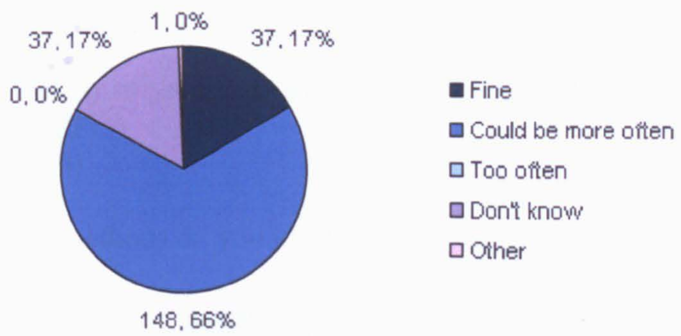
15. Have you taken a dog on holiday with you in the past year?
63% No (138)
37% Yes (80)

16. Have you taken a dog on holiday elsewhere in Europe with you in the past year?
100% No (218)
0% Yes (1)

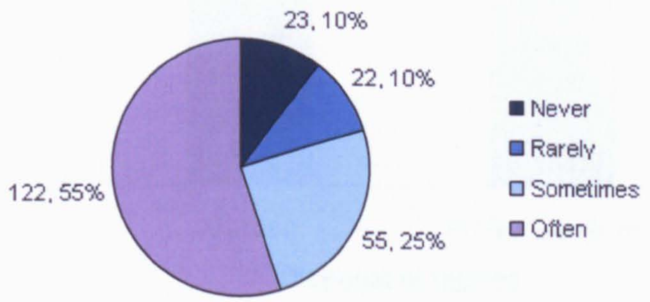
17. How do you feel about the number of poo bins in your area?



18. How do you feel about the regularity of emptying the bins?

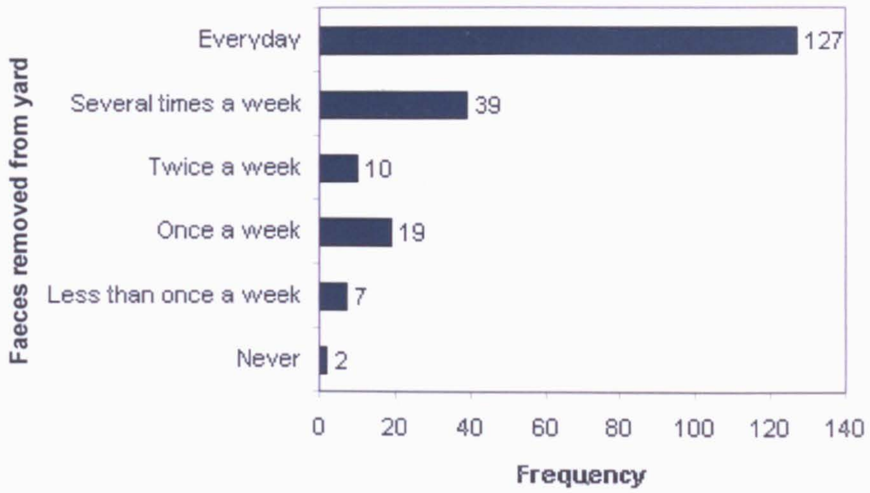


19. How often do you use the poo bins provided in your area?



20. a) Do any of your dogs ever pass faeces in the garden/yard area?
92% Yes (205)
8% No (19)

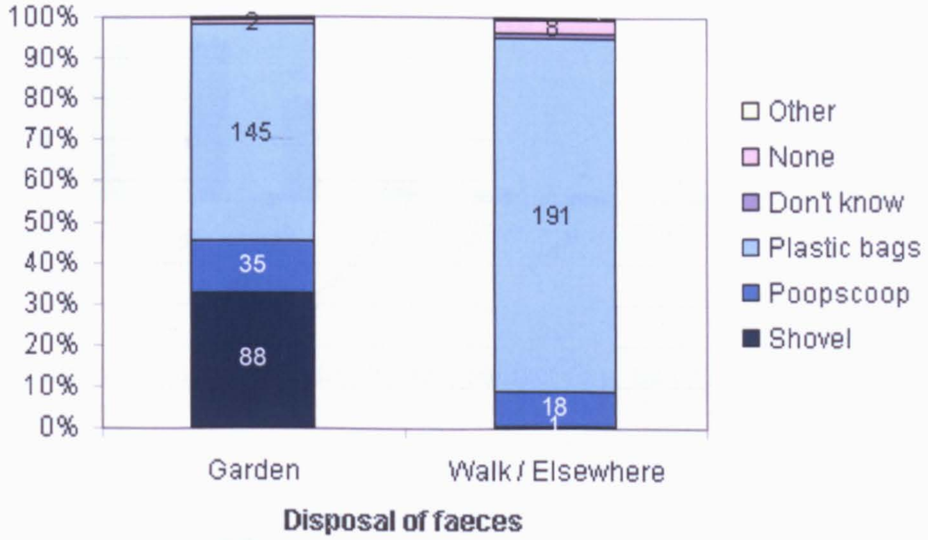
b) How often are faeces removed from the garden/yard?



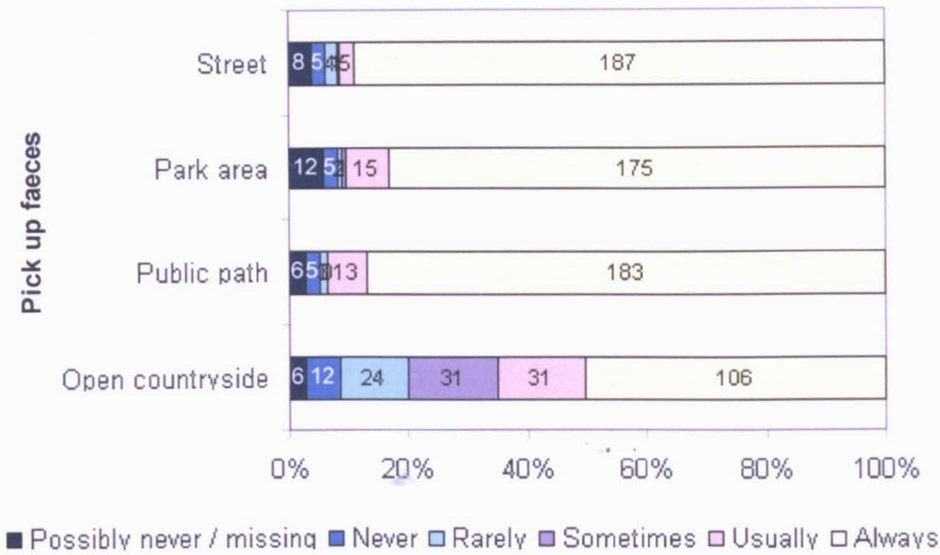
c) Which methods do you use for disposing of faeces from the garden/yard area?
See Q. 21b

21. a) Do any of your dogs ever pass faeces on a walk?
91% Yes (203)
9% No (20)

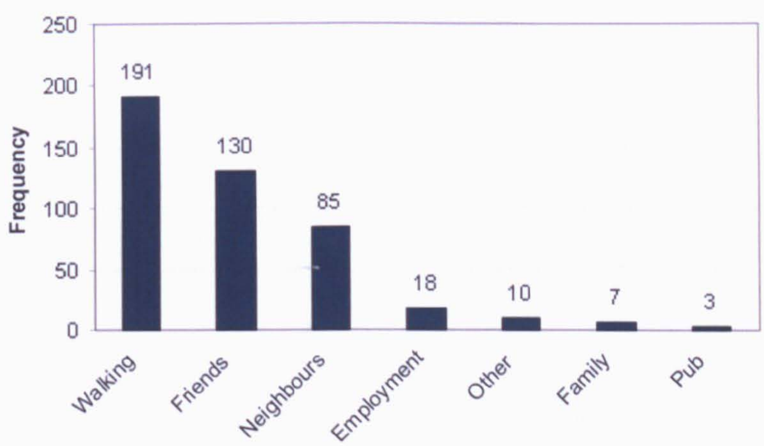
b) Which methods do you use for disposing of faeces elsewhere (e.g. on a walk)?



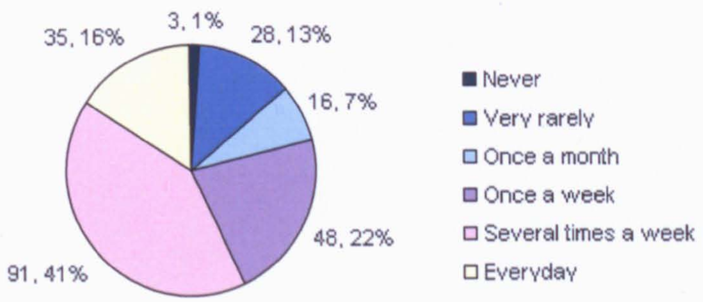
22. If your dog passes motions (faeces) in the following areas, how often do you pick it up?



23. a) In what circumstances do you personally come into contact with other dogs (not your own)?



b) How often do you come into physical contact (e.g. touch, petting, dog jumping up) with other dogs?



24. Please provide the name of your current veterinary practice.
Information withheld.

25. As the person completing the questionnaire, were you also the person interviewed at the door?
81% Yes (178)
19% No, different person (41)

26. Would you be willing to participate further in our studies in the future?
88% Willing (192)
12% Not willing (25)

For more information or if you have any questions please contact:

Carri Westgarth BSc(Hons)
Veterinary Clinical Science
University of Liverpool
Leahurst
Neston
Wirral
CH64 7TE

Tel: 0151 795 6011

Email: carri.westgarth@liverpool.ac.uk

FACULTY *of* VETERINARY SCIENCE

THE UNIVERSITY *of* LIVERPOOL

FACULTY *of* VETERINARY SCIENCE

Survey of Dogs in the Community

Why are the University conducting this study?

Humans and dogs have lived together for thousands of years. The dog is one of the most common household pets and many people have a close relationship with their dog.

Staff at the Liverpool Veterinary School, Leahurst, are conducting a study in the Little Neston area investigating the role of dogs in the community. We would be very grateful if you would be willing to participate in this study.

We are investigating the common types of interactions that occur between dogs and their owners. We would also like to know details about how people look after their dogs.

We are looking at the types of contact dogs have with other dogs, for example when on a walk. We would specifically like to know where the dog is walked.

As we wish to identify why some people currently own dogs and others do not, we hope that people both with or without a dog will help us.

How can I participate in the study?

Over the next few weeks we will be knocking on doors in your area collecting information in the form of a short questionnaire.

All information given will be strictly confidential and only used for the study. You do not need to give a name. If the time of calling is inconvenient we will call back at another time. If you do not want to be involved in the study, please tell us when we call.

We will ask some simple questions to both dog owners and non-dog owners. If you own a dog and would be willing to participate further we will then ask some basic questions about each dog and leave a more detailed questionnaire for you to fill in, in your own time, and post back to us in a S.A.E. To thank you for your time we will give you vouchers for **£2 off Royal Canin** pet food and for **5% discount at Glenbrittle Animal Centre**, Neston which includes kennels, grooming, and a pet store.

All interviewers will carry identity cards

46168

THE UNIVERSITY *of* LIVERPOOL

Dogs in the Community Survey
Section A

Reference ☐☐☐☐

House number ☐☐☐ House name ☐☐☐☐☐☐☐☐☐☐

Street name ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ Postcode ☐☐☐☐ ☐☐☐

House type
- ☐ Detached
- ☐ Semi-detached
- ☐ Terraced
- ☐ Flat/apartment/bedsit
- ☐ Other ______________________

Street Type
- ☐ Cul-de-sac
- ☐ Through road

Hello, my name is _________, I am from Leahurst, the University of Liverpool Veterinary School. We are conducting a survey in the area about dog ownership and behaviour.

Would you mind if I asked you a few questions? It should only take a couple of minutes. We would like to interview both dog-owners and non-dog owners so that we can compare the differences between them.

Is this a convenient time? (Would you like me to call back at another time?)

The information that you give will only be used for the study and is confidential, we do not need to take a name.

Survey status

				Date	Time
First Knock	☐ In	☐ Not in	☐ Asked to call back		
Second Knock	☐ In	☐ Not in	☐ Asked to call back		
Third Knock	☐ In	☐ Not in	☐ Asked to call back		
Fourth Knock	☐ In	☐ Not in	☐ Asked to call back		

☐ Case

☐ Control

☐ Fully Interviewed ☐ Part interviewed ☐ Not willing to participate

46168

1. a) Are there any pets in the household? ☐ Yes **(Please answer Q1b and c)**

☐ No **(Go to Q2)**

b) How many dogs are there in the household (sleep most nights of the week)? ☐☐

c) Are there any other animals owned by the household?

☐ Cat ☐ Birds ☐ Fish ☐ Horse ☐ Livestock ☐ Reptiles/amphibians

☐ Rabbit/Guinea pig/Hamster/other small mammals ☐ Other ________

*Please answer **Q2** only for households that **do not** own a dog. Dog-owning households may **skip to Q3**.*

2. a) Are there any particular reasons why you do not own a dog at this time? (Please mark with a cross all that apply)

☐ Allergic ☐ Work / Out all day ☐ Too expensive ☐ Not enough time

☐ Do not like dogs ☐ Go away a lot ☐ Rented property ☐ Emotional reasons

☐ Create mess ☐ Have cats ☐ Young children around ☐ Not considered it

☐ Other (please specify) ________

b) Have you owned dogs in the past? ☐ Yes **(Please answer Q2c)**

☐ No **(Go to Q3)**

c) How long ago did you own your last dog? ☐☐ Years ☐☐ Months

Has dog - Now I am going to ask you a couple of questions about your general contact with other dogs, (not your own).
No dog - Now I am going to ask you a couple of questions about your general contact with dogs.

3. a) How often do you come into physical contact (e.g. touch, petting, dog jumping up) with other dogs?

☐ Every day ☐ Several times a week ☐ Once a week ☐ Once a month ☐ Very rarely ☐ Never

If Never indicated, please now skip to Q4.

b) In what circumstances do you come into contact with other dogs? (Mark with a cross all that apply).

☐ Walking ☐ Friends with dogs ☐ Employment ☐ Neighbours

☐ Family ☐ Other (please describe) ________

4. a) Does the household have a garden or yard?

☐ Garden ☐ Yard ☐ Both ☐ No **(Go to Q5)**

b) Is the garden/yard used for recreational purposes ,weather permitting, e.g. eating, children playing, gardening?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often

46168

If you do not mind, I would now like to ask some questions about the people living in the household.

5. a) How many people are currently resident (as in sleep most nights of the week) in the household? ☐☐

b) Complete for each person:

	Sex	Age group	Job Type	
1	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time
2	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time
3	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time
4	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time
5	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time
6	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time
7	☐ Male ☐ Female	<5 ☐ 6-15 ☐ 16-19 ☐ 20-29 ☐ 30-59 ☐ 60-74 ☐ 75+ ☐		☐ Fulltime ☐ Part-time

Please enter under Job Title if any of the following apply:
Unemployed, full-time student, retired, looking after home/family, permanently sick/disabled.

6. FOR DOG-OWNERS

That is the end of the first section. I would now like to take a few details about your dog(s) and then leave you with a longer questionnaire to fill in and return in the envelope provided. In return I will send you two vouchers, for £2 off Royal Canin pet food and 5% discount at Glenbrittle Kennels in Neston.

Are you willing to participate further in this study? ☐ Yes ☐ No

FOR NON DOG-OWNERS

That is the end of the questions. Thank you very much for taking part in our study.

12610

THE UNIVERSITY of LIVERPOOL

Dogs in the Community Survey
Section B

Reference ☐☐☐☐

Dog Name ☐☐☐☐☐☐☐☐☐☐ Dog Number ☐☐☐ **Office use only**

Section B is to be completed <u>for each dog</u> in the household by the interviewer. Begin by asking for the name of each dog and enter at the top of a copy of section B for each dog. Then proceed, for example, 'What type of dog is _____?'

1. Type of dog

☐ Breed (Please state) ______

☐ Known cross (Please state) ______

☐ Unknown

Colour ______

2. Size of dog (when adult)

☐ Toy ☐ Small (terrier) ☐ Medium (collie/spaniel) ☐ Large (labrador/GSD) ☐ Giant (great dane)

3. Age of dog

Known ☐☐ Years ☐☐ Months ☐ Unknown

Estimated ☐☐ Years ☐☐ Months

4. Sex of dog ☐ Male ☐ Female ☐ Unknown

5. Is the dog neutered? ☐ Yes ☐ No ☐ Unknown

6. Have you owned this dog all of its life (since it was a puppy at 12 weeks)?

☐ Yes ☐ No - At what age? ______

7. Where did you get the dog?

☐ From the person who bred it
☐ Rescue centre
☐ Through a friend
☐ Found as a stray
☐ Gift
☐ Pet shop
☐ Other (please specify) ______

8. Who carries out dog duties (feeding, exercising) for this dog?

☐ One main person (number from Section A) ☐
☐ Shared

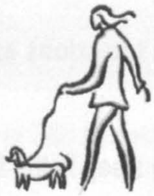
Thank you very much for answering those questions. I would be very grateful if I could leave you with a further questionnaire about your dog's activities for you to fill in, in your own time, and return in the pre-paid envelope supplied. The questionnaire takes approximately 15 minutes to complete.
When I receive it I will post to you two money-off vouchers to thank you for taking part. They will be for £2 off Royal Canin pet food and for 5% discount at Glenbrittle Animal Centre, Neston.
Please could the person who spends the most time with the dog and walks it, fill in the questionnaire, as they will be more able to answer the questions effectively.

Leave household with a Section C for each dog with name of dog completed.
Leave household with one Section D with house location marked on map with a cross, and a pre-paid envelope to return the two sections.

THE UNIVERSITY *of* LIVERPOOL

Dogs in the Community Survey

Section C



Reference

Carri Westgarth BSc
Veterinary Clinical Science, University of Liverpool
Leahurst, Neston, CH64 7TE
0151 795 6011 carri.westgarth@liverpool.ac.uk

Thank you for taking part in this study. Any information that you give will only be used for the purposes of this study and is confidential, we do not take a name - **Please be as accurate as possible.**

To thank you for participating in this study you will receive two vouchers; £2 off Royal Canin pet food and for 5% discount at Glenbrittle Animal Centre, Neston, which includes a kennels and pet store. These vouchers will be dispatched to your household after we receive your completed questionnaires in the pre-paid envelope supplied.

Instructions

This section (green) is to be completed once for each dog in the household. Please can the person that is most responsible for dog care (spends most time with the dog, walks it) complete the questionnaire as they will be more able to answer the questions effectively.

This copy of Section C (green) belongs to:

Dog Name

Dog Number

Office use only

Answering the questions

Please complete the questionnaire in **Black or Blue** ink and use capital letters.

Where a small box is given next to each choice please indicate your choice with a **cross** in the box __not__ a tick:

☒ Male ☐ Female

If you make a mistake or decide to change your answer please fill in the first box completely and put a clear cross in the new box.

If given a blank box, please write your answer clearly, inside the box lines.

The following questions are about where the dog goes and what it does in the household.

1. How often does the dog sleep in the following places at night? (Please indicate answer for all locations)

	Never	Rarely	Sometimes	Often	Always
Outside	☐	☐	☐	☐	☐
Kitchen	☐	☐	☐	☐	☐
Bedroom (on floor)	☐	☐	☐	☐	☐
Bedroom (on human bed)	☐	☐	☐	☐	☐
Living area	☐	☐	☐	☐	☐
Other room (please describe)	☐	☐	☐	☐	☐

2. How often does the dog rest in the following places during the day when you are in the house? (Please indicate answer for all locations)

	Never	Rarely	Sometimes	Often	Always
Outside	☐	☐	☐	☐	☐
Kitchen	☐	☐	☐	☐	☐
Bedroom (on floor)	☐	☐	☐	☐	☐
Bedroom (on human bed)	☐	☐	☐	☐	☐
Living area	☐	☐	☐	☐	☐
Other room (please describe)	☐	☐	☐	☐	☐

3. When you are in the house, where in the house does the dog have access? (Please cross one).

- ☐ Everywhere
- ☐ Everywhere except bedroom
- ☐ Restricted to downstairs
- ☐ Restricted to kitchen
- ☐ Restricted to living area
- ☐ Restricted to utility room
- ☐ Restricted to outside
- ☐ Other (please describe)

4. When you are **NOT** in the house, where in the house does the dog have access? (Please cross one).

- ☐ Everywhere
- ☐ Everywhere except bedroom
- ☐ Restricted to downstairs
- ☐ Restricted to kitchen
- ☐ Restricted to living area
- ☐ Restricted to utility room
- ☐ Restricted to outside
- ☐ Other (please describe)

5. Does the dog lie on furniture? ☐ Never ☐ Rarely ☐ Sometimes ☐ Often

The following questions are about the dog's interaction with people.

6. a) In an average day, estimate how much time the dog spends actively interacting with people in the household? (e.g. games, cuddles, training, grooming, not just resting in the same room).

☐ Up to half hour ☐ Half to one hour ☐ 1-2 hours ☐ 2-4 hours ☐ Over 4 hours

b) Is this interaction all with one person or with a variety of persons? ☐ One person ☐ More than one person

7. In an average week, how much time in total do you spend grooming your dog? (e.g., brushing, bathing).

☐ None ☐ Less than 15 mins ☐ 15mins - half hour ☐ Half - 1 hour ☐ Over 1 hour

8. How often does the dog lie on a persons lap? ☐ Never ☐ Rarely ☐ Sometimes ☐ Often

9. When your dog is greeting **visitors**, how often are the following types of behaviour seen? (Please indicate for each behaviour).

	Never	Rarely	Sometimes	Often
Sniffing/nudging with nose	☐	☐	☐	☐
Jumping up	☐	☐	☐	☐
Licking face	☐	☐	☐	☐
Licking hands	☐	☐	☐	☐
Barking	☐	☐	☐	☐
Growling	☐	☐	☐	☐
Hiding	☐	☐	☐	☐

10. When your dog is interacting with **household members**, how often are the following types of behaviour seen? (Please indicate for each behaviour).

	Never	Rarely	Sometimes	Often
Sniffing/nudging with nose	☐	☐	☐	☐
Jumping up	☐	☐	☐	☐
Licking face	☐	☐	☐	☐
Licking hands	☐	☐	☐	☐
Barking	☐	☐	☐	☐
Growling	☐	☐	☐	☐
Hiding	☐	☐	☐	☐

11. When household members play with the dog, how often are the following types of games used?

	Never	Rarely	Sometimes	Often
Fetch ball / object	☐	☐	☐	☐
Tug-of-war (e.g with ragger)	☐	☐	☐	☐
Hide and seek	☐	☐	☐	☐
Rough and tumble (wrestling)	☐	☐	☐	☐
Chase	☐	☐	☐	☐
Other (please describe)	☐	☐	☐	☐

The following questions apply to when the dog is <u>outside</u> of the household.

12. Does the dog ever roam unattended away from the premises?

- ☐ No, confined to secure area
- ☐ Generally confined but has escaped in past
- ☐ Not confined but generally chooses not to roam
- ☐ Yes, allowed to roam

13. How often is your dog taken for a walk?

- ☐ Never **(Please go to Q19)**
- ☐ Less than once a week
- ☐ Once a week
- ☐ Several times a week
- ☐ Once a day
- ☐ Twice a day
- ☐ Three times a day
- ☐ Other (please describe) ______

14. a) Estimate how many **people** your dog meets and interacts with, outside the household, on a typical **week day**?

☐ None ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 11-15 ☐ 15+ ☐ Don't know

b) Estimate how many **people** your dog meets and interacts with, outside the household, on a typical **weekend day**?

☐ None ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 11-15 ☐ 15+ ☐ Don't know

c) When your dog sees a person, how likely is the dog to greet them and make physical contact?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often

15. a) Estimate how many **dogs** your dog meets and interacts with, outside the household, on a typical **week day**?

☐ None ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 11-15 ☐ 15+ ☐ Don't know

b) Estimate how many **dogs** your dog meets and interacts with, outside the household, on a typical **weekend day**?

☐ None ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 11-15 ☐ 15+ ☐ Don't know

c) When your dog sees another dog, how likely is your dog to greet them and make physical contact? (Sniffing, playing).

☐ Never ☐ Rarely ☐ Sometimes ☐ Often

16. For the following behaviours, please indicate how much the dog shows when interacting with other dogs on a walk.

	Never	Rarely	Sometimes	Often
Playful (bowing, chasing)	☐	☐	☐	☐
Sniffing	☐	☐	☐	☐
Ignore	☐	☐	☐	☐
Aggression (growling, snapping)	☐	☐	☐	☐

17. a) When the dog is walked, is it ever on a lead? ☐ Yes ☐ No **(Please go to Q18b)**

b) What type of lead is used for this dog? ☐ Short lead ☐ Extendable flexi-lead ☐ Both

18. a) Is the dog ever allowed off lead? ☐ Yes, in certain areas ☐ Yes, most of the time ☐ No **(Go to Q19)**

b) When the dog is off lead, is it....

☐ Always within sight ☐ Can go out of sight but mostly in sight ☐ Often out of sight

19. Does the dog have contact with people and other dogs in any of the following situations (a - g)?
For all questions, information on names and locations of the premises will be confidential and are only asked in order to calculate distances travelled and identify common establishments.

a) Training classes

☐ Never
☐ Once a year
☐ Every few months
☐ Once a month
☐ Once a week or more

If so, name and location?

b) Grooming parlour

☐ Never
☐ Once a year
☐ Every few months
☐ Once a month
☐ Once a week or more

If so, name and location?

c) Boarding kennels

☐ Never
☐ Once a year
☐ Every few months
☐ Once a month
☐ Once a week or more

If so, name and location?

d) Work environment

☐ Never
☐ Once a year
☐ Every few months
☐ Once a month
☐ Once a week or more
☐ Every day

If so, please describe

e) Friends or relatives houses

☐ Never
☐ Once a year
☐ Every few months
☐ Once a month
☐ Once a week or more
☐ Every day

f) School (e.g pick up children)

☐ Never
☐ Once a year
☐ Every few months
☐ Once a month
☐ Once a week or more
☐ Every day

g) Any other contact situations that you can think of? (Please describe including frequency).

The following questions are about health and diet of the dog.

20. a) What type of food does the dog eat as the main diet? (Please cross all that apply).

☐ Tinned meat ☐ Cooked meat ☐ Raw meat ☐ Other (please specify)

☐ Dry complete ☐ Dry biscuit or mixer ☐ Vegetables

b) Is the dog fed in the kitchen? ☐ Yes ☐ No

21. Does the dog get commercial dog treats? ☐ Never ☐ Rarely ☐ Sometimes ☐ Often

22. a) Does the dog get human food tit-bits? ☐ Yes ☐ No **(Go to Q23)**

b) Does the dog receive human food tit-bits in the following situations?

	Never	Rarely	Sometimes	Often
From a persons hand	☐	☐	☐	☐
Leftovers in dog dinner bowl	☐	☐	☐	☐
Straight from a persons plate	☐	☐	☐	☐
From floor when been dropped	☐	☐	☐	☐

23. Do you ever feed your dog raw meat? ☐ Never ☐ Rarely ☐ Sometimes ☐ Often

24. Does your dog ever find and eat raw carcasses, e.g. dead bird or rabbit?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often

25. Does your dog ever roll in carcasses or faeces (animal droppings)?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often

26. Does your dog ever find and eat dog faeces? (Its own or from another dog).

☐ Never ☐ Rarely ☐ Sometimes ☐ Often

27. a) Has this dog been to a veterinary surgeon in the past year? ☐ Yes ☐ No **(Go to Q28)**

b) Please state why dog visited veterinary surgeon in past year? (Please cross all that apply).

☐ Vaccination ☐ General check up ☐ Vomiting and/or diarrhoea ☐ Respiratory/breathing problems

☐ Other (please describe)

28. a) Has the dog been given a **flea** treatment recently (in the past three months)?

☐ No ☐ Unknown ☐ Yes (please name if known)

b) Has the dog been given a **worming** treatment recently (in the past three months)?

☐ No ☐ Unknown ☐ Yes (please name if known)

c) Is the dog on any other medication?

☐ No ☐ Yes (Please describe what for)

29. Please indicate how often your dog toilets in the following areas.

	Passes urine				Passes motions (faeces)			
	Never	Rarely	Sometimes	Often	Never	Rarely	Sometimes	Often
Garden / Yard	☐	☐	☐	☐	☐	☐	☐	☐
In the house	☐	☐	☐	☐	☐	☐	☐	☐
On walks	☐	☐	☐	☐	☐	☐	☐	☐

Thank you for completing Section C (green) of the questionnaire.

If you have another dog, now fill in a copy of Section C (green) for that dog also.

Once you have filled in a copy for each dog in the household, go on to complete a copy of Section D (white) for your household.

THE UNIVERSITY of LIVERPOOL

Dogs in the Community Survey
Section D

Reference

Carri Westgarth BSc
Veterinary Clinical Science, University of Liverpool
Leahurst, Neston, CH64 7TE
0151 795 6011 carri.westgarth@liverpool.ac.uk

Thank you for taking part in this study. Any information that you give will only be used for the purposes of this study and is confidential, we do not take a name - **Please be as accurate as possible.**

To thank you for participating in this study you will receive two vouchers; £2 off Royal Canin pet foods and for 5% discount at Glenbrittle Animal Centre, Neston, which includes a kennels and pet store. These vouchers will be dispatched to your household after we receive your completed questionnaires in the pre-paid envelope supplied.

Instructions

This section (white) is to be completed only once for the whole household. The questions are general and apply to all dogs in the household. Please can the person that is most responsible for dog care (spends most time with the dog, walks it) complete the questionnaire as they will be more able to answer the questions effectively.

Answering the questions

Please complete the questionnaire in **Black or Blue** ink and use capital letters.

Where a small box is given next to each choice please indicate your choice with a **cross** in the box **not a tick**:

☒ Male ☐ Female

If you make a mistake or decide to change your answer please fill in the first box completely and put a clear cross in the new box.

If given a blank box, please write your answer clearly, inside the box lines.

1. Have you owned dogs in the past? ☐ Yes ☐ No - first dog

2. Why did you choose to get a dog? (Please mark with a cross all that apply).

☐ Companionship ☐ Protection ☐ Interest / hobby ☐ To show / breed

☐ Exercise ☐ Working dog ☐ Always had a dog ☐ Family member wanted a dog

☐ Gift ☐ Other (please describe) [ ]

3. Do you wash your hands... ?

	Never	Rarely	Sometimes	Usually	Always
Before eating	☐	☐	☐	☐	☐
After touching a dog	☐	☐	☐	☐	☐
After picking up faeces	☐	☐	☐	☐	☐

The following questions are about interaction with people.

4. On average, how often do visitors come into the house? (Choose one option for each).

ADULTS	CHILDREN (Not including your own)
☐ Every day	☐ Every day
☐ Several times a week	☐ Several times a week
☐ Once a week	☐ Once a week
☐ Once a month	☐ Once a month
☐ Once every several months	☐ Once every several months
☐ Once a year	☐ Once a year
☐ Never	☐ Never

5. How often do household members interact or play with the dog(s) in the garden area?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Not got a garden

The following questions are about when the dog is away from the household.

6. How often is your dog taken for a walk?

☐ Never **(Please go to Q15)**
☐ Less than once a week
☐ Once a week
☐ Several times a week
☐ Once a day
☐ Twice a day
☐ Three times a day
☐ Other (please describe) [ ]

7. How long on average is each walk? ☐ 0-15 mins ☐ 16 - 30 mins ☐ 31 mins - 1 hour ☐ Over 1 hour

8. a) Are dog walks at a regular time of day? ☐ Yes ☐ No, varies **(Go to Q9)**

b) Approximately what time of day is your dog walked? (If you walk more than once a day, tick for each time).

☐ 6 - 9am ☐ 9am - 12pm ☐ 12 - 3pm ☐ 3 - 6pm ☐ 6 - 9pm ☐ 9pm - midnight

☐ Other (please describe) ______

9. Which types of area do you often walk in? (Mark with a cross all that apply)

☐ Streets ☐ Park (urban) ☐ Beach or marsh ☐ Countryside ☐ Farmland

☐ Other (please describe) ______

10. Do you regularly (mostly daily) walk in the same place? ☐ Yes ☐ No, varies

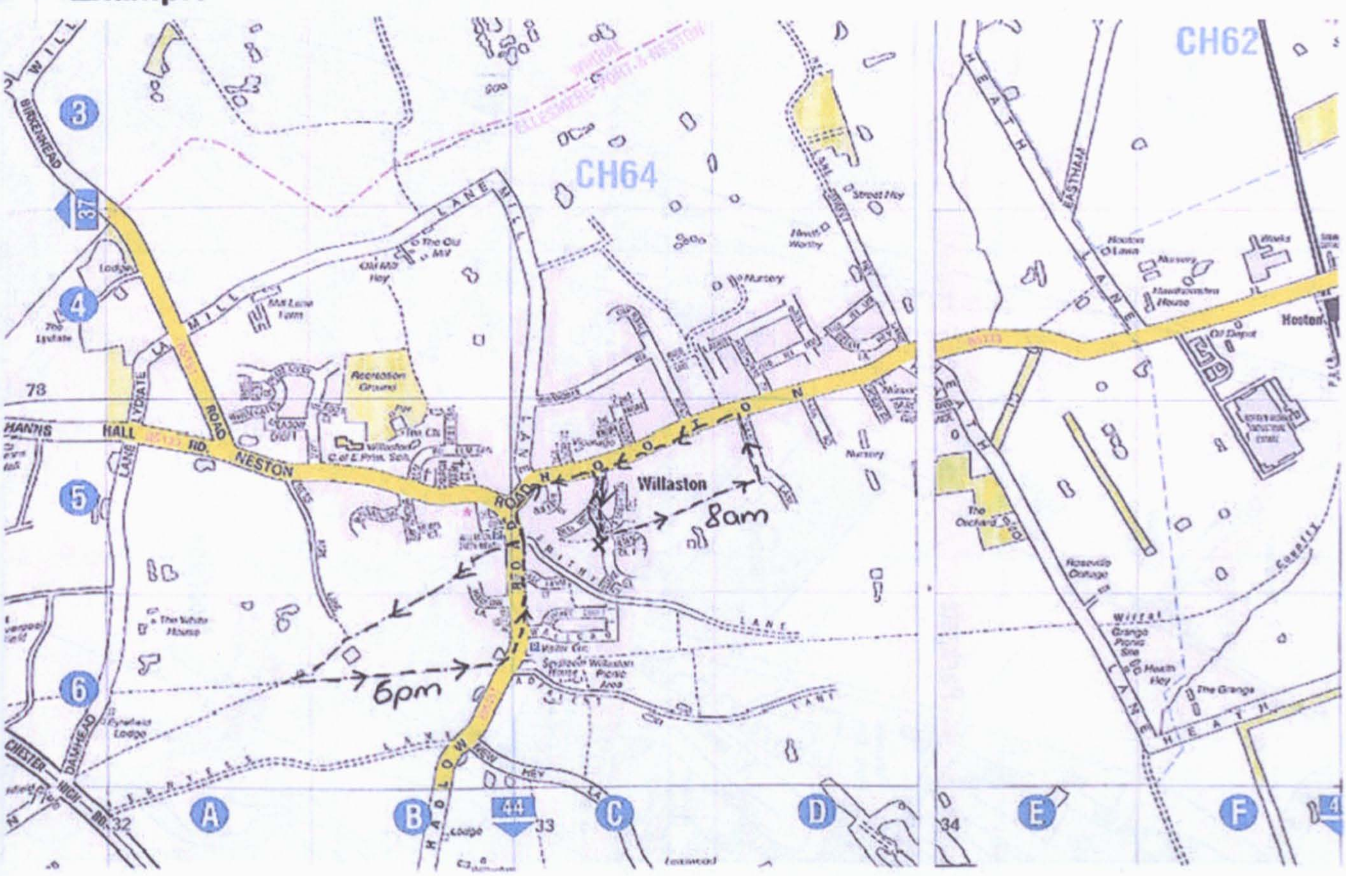
11. The following question involves drawing on a map of the area to describe the regular local routes that you walk your dog.

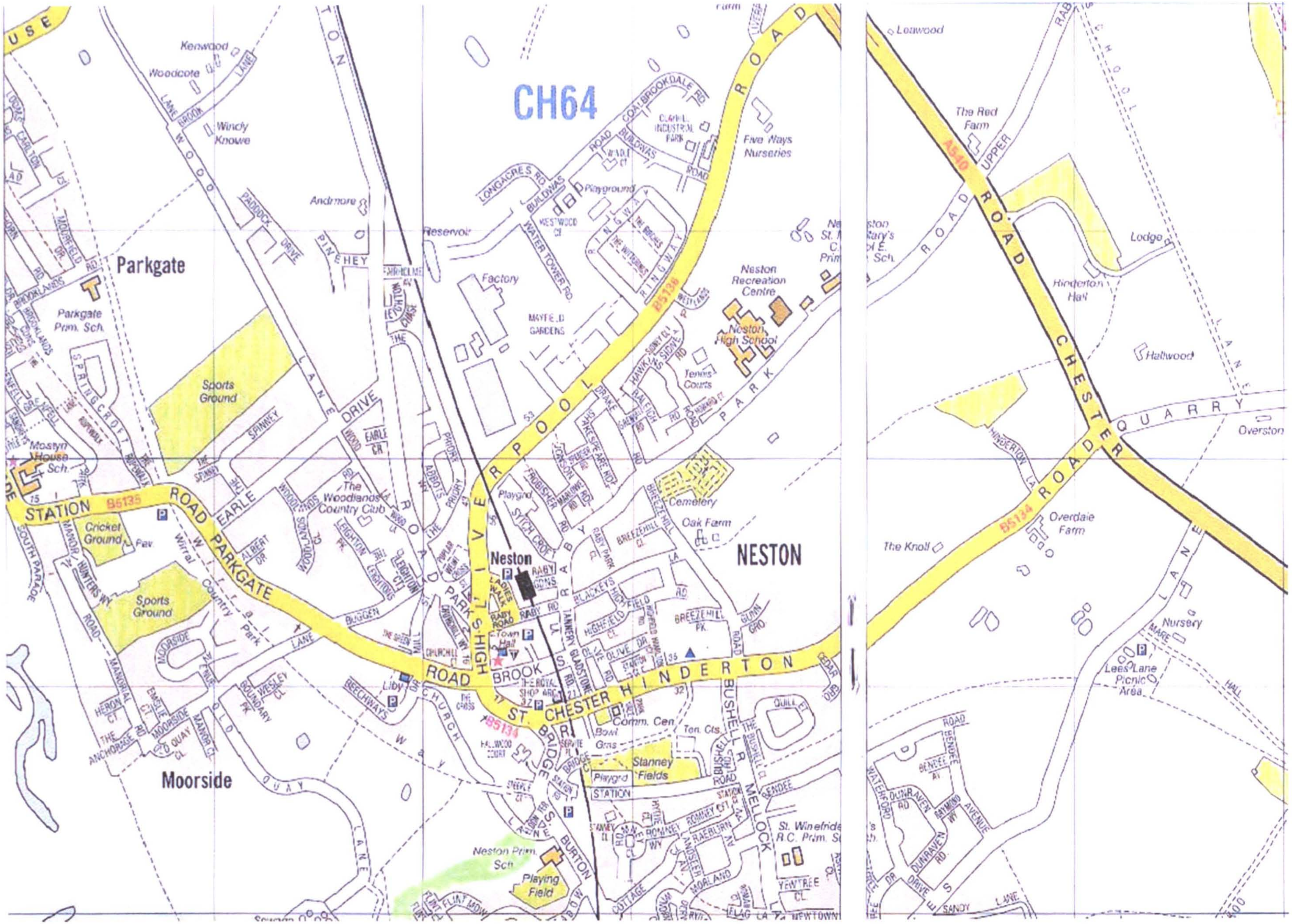
On the maps given, use your pen to trace the route of any walks that you often use, that are covered by the map. Please also label approximate times if they are at a certain time each day.

If your walk leaves the edge of the map supplied please indicate this and continue marking the rest of the route.

The following map is provided as an example..

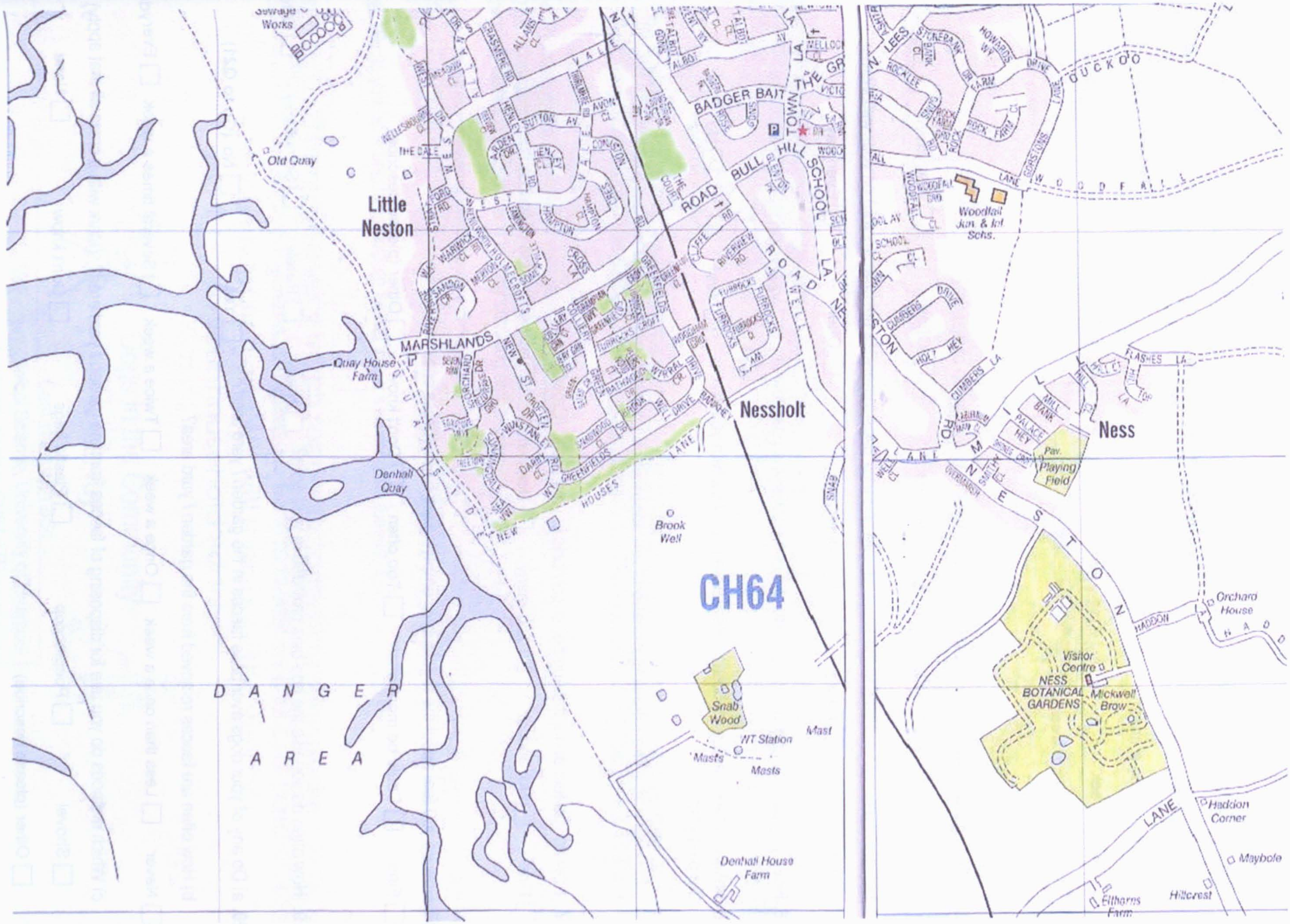
Example





Please now complete:

8603233106



Sewage Works
Old Quay
Little Neston
Marshlands
Quay House Farm
Denhall Quay
DANGER AREA
Nesholt
Brook Well
CH64
Snab Wood
WT Station
Mast
Masts
Denhall House Farm
Badger Bait
Bull Hill
School La.
Town La.
Woodfall Jun. & Inf. Schs.
Ness
Pav.
Playing Field
Orchard House
Visitor Centre
NESS BOTANICAL GARDENS
Mickwell Brow
Haddon Corner
Maybole
Elthorns Farm
Hillcrest
Woodfall Lane
Cuckoo
Flashes La.
Neston Rd.
Haddon Lane

3110233104

12. Do you ever travel in the car or public transport to walk the dog(s) in areas not included on the map?

- ☐ Never
- ☐ Less than once a month
- ☐ Once a month
- ☐ Several times a month
- ☐ Once a week
- ☐ Several times a week
- ☐ Everyday

If so, please name locations

13. Is the dog ever walked with other dogs known to you (e.g. in a group of friends)?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Everyday

14. Have you ever noticed seeing the same people and their dogs (otherwise unknown to you) on your walks?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Everyday

15. Have you taken a dog on holiday with you in the UK in the past year? ☐ Yes ☐ No

16. Have you taken a dog on holiday elsewhere in Europe with you in the past year? ☐ Yes ☐ No

The following questions are about when your dog passes motions (faeces).

17. How do you feel about the number of poo bins in your area? (Cross one)

☐ Fine ☐ Not enough ☐ Too many ☐ Don't know ☐ Other (please describe)

18. How do you feel about the regularity of emptying the bins? (Cross one)

☐ Fine ☐ Could be more often ☐ Too often ☐ Don't know ☐ Other (please describe)

19. How often do you use the poo bins provided in your area? ☐ Never ☐ Rarely ☐ Sometimes ☐ Often

20. a) Do any of your dogs ever pass faeces in the garden / yard area? ☐ Yes ☐ No **(Go to Q21)**

b) How often are faeces removed from the garden / yard area?

☐ Never ☐ Less than once a week ☐ Once a week ☐ Twice a week ☐ Several times a week ☐ Everyday

c) Which methods do you use for disposing of faeces from the garden / yard area? (Mark with a cross all that apply)

☐ Shovel ☐ Poop-scoop ☐ Plastic bags ☐ Don't know ☐ None

☐ Other (please describe)

21. a) Do any of your dogs ever pass faeces on a walk? ☐ Yes ☐ No **(Go to Q23)**

b) Which methods do you use for disposing of faeces elsewhere (e.g.on a walk)? (Mark with a cross all that apply)

☐ Shovel ☐ Poop-scoop ☐ Plastic bags ☐ Don't know ☐ None

☐ Other (please describe) ______________________

22. If your dog passes motions (faeces) in the following areas, how often do you pick it up?

	Never	Rarely	Sometimes	Usually	Always
Public path	☐	☐	☐	☐	☐
Open countryside	☐	☐	☐	☐	☐
Park area	☐	☐	☐	☐	☐
Street	☐	☐	☐	☐	☐

23. a) In what circumstances do **you** personally come into contact with **OTHER DOGS (not your own)**? (Mark with a cross all that apply).

☐ Walking ☐ Friends with dogs ☐ Employment ☐ Neighbours

☐ Other (please describe) ______________________

b) How often do you come into physical contact (e.g. touch, petting, dog jumping up) with **other dogs**?

☐ Every day ☐ Several times a week ☐ Once a week ☐ Once a month ☐ Very rarely ☐ Never

24. Please provide the name of your current veterinary practice. (This information will be confidential and is only asked to calculate distance travelled and identify common establishments.) ______________________

25. As the person completing the questionnaire, were you also the person interviewed at the door? ☐ Yes ☐ No

26. Would you be willing to participate further in our studies in the future? ☐ Yes ☐ No

Thank you very much for participating in this study. Please post your completed forms back in the pre-paid envelope supplied and we will then post the vouchers to your household address.

Dogs in the Community Survey

Carri Westgarth BSc
Veterinary Clinical Science, University of Liverpool
Leahurst, Neston, CH64 7TE
0151 795 6011 carri.westgarth@liverpool.ac.uk

BMC Veterinary Research

BioMed Central

Research article

Open Access

Factors associated with dog ownership and contact with dogs in a UK community

Carri Westgarth*[1], Gina L Pinchbeck[1], John WS Bradshaw[3], Susan Dawson[1], Rosalind M Gaskell[2] and Robert M Christley[1]

Address: [1]Department of Veterinary Clinical Science, University of Liverpool, Leahurst, Neston, Cheshire, CH64 7TE, UK, [2]Veterinary Pathology, University of Liverpool, Leahurst, Neston, Cheshire, CH64 7TE, UK and [3]Anthrozoology Institute, Department of Clinical Veterinary Science, University of Bristol, Langford House, Langford, North Somerset, BS40 5DU, UK

Email: Carri Westgarth* - carri.westgarth@liverpool.ac.uk; Gina L Pinchbeck - ginap@liverpool.ac.uk; John WS Bradshaw - J.W.S.Bradshaw@bristol.ac.uk; Susan Dawson - s.dawson@liverpool.ac.uk; Rosalind M Gaskell - r.m.gaskell@liverpool.ac.uk; Robert M Christley - robc@liverpool.ac.uk

* Corresponding author

Published: 3 April 2007

BMC Veterinary Research 2007, **3**:5 doi:10.1186/1746-6148-3-5

Received: 18 October 2006

Accepted: 3 April 2007

This article is available from: http://www.biomedcentral.com/1746-6148/3/5

Abstract

Background: Dogs are popular pets in many countries. Identifying differences between those who own dogs or have contact with dogs, and those who do not, is useful to those interested in the human-animal bond, human health and for provision of veterinary services. This census-based, epidemiological study aimed to investigate factors associated with dog ownership and contact with dogs, in a semi-rural community of 1278 households in Cheshire, UK.

Results: Twenty-four percent of households were identified as dog-owning and 52% owned a pet of some type. Multivariable logistic regression suggested that households were more likely to own a dog if they had more occupants (five or more); if they had an adult female household member; or if they owned a horse. The age structure of the households was also associated with dog ownership, with households containing older children (between six and 19 years of age) and young adults (between 20 and 29 years of age), more likely to own dogs. We also found that dog owning households were more likely to be multi-dog households than single-dog if they also owned a cat or a bird, or if the household contained a person of 20–29 years old. Dog owners reported increased contact with dogs, other than their own, compared to those that did not own dogs and this contact appeared to be mainly through walking.

Conclusion: Some household types are more likely to own a dog than others. This study supports the suggestion that dogs are more common in families who have older children (6–19 years), as has been generally observed in other countries. Dog owners are also more likely to have contact with dogs other than their own, compared with those not owning a dog.

Background

Humans and dogs have lived in close proximity for thousands of years. The effect of pet ownership on human health has been studied on a number of occasions but has been somewhat inconclusive due to the difficulties in studying such a complex relationship and assigning direction of causation [1]. Pets provide companionship and also probably confer physiological health and psychological benefits [1-5]. For example, pet owners have fewer doctors visits [6] and longer survival following heart attack [7], compared to non-pet owners. Katcher and Friedmann [4] suggested seven common functions of pet ownership: companionship; something to care for; something to touch and fondle; something to keep one busy; a focus of attention; exercise and safety. Pets have also been indicated to have important roles in enhancing child development [4,8,9], the wellbeing of older people [4,9,10] and may also be used in a therapeutic setting [8,10,11]. However, it has become increasingly apparent that pets are an important source of zoonotic infections. Approximately 30 to 40 organisms that cause zoonotic infections are known in companion animals, including dogs [12]. Some groups in human society are at greater risk of zoonotic infection due to their immune system or behaviour, for example young children, the elderly, pregnant women and the immunocompromised [12,13].

Virtually everyone in the community is in contact with either companion animals or their products, including excreta [14]. Dogs and cats are the most popular pets in the UK, although dog ownership has declined slightly over recent years [15]. In 2004 there were approximately 5.2 million dog owning households in the UK (21% of households), owning 6.8 million dogs [15]. The demographics of pet ownership are of health, psychological and social science interest, applicable to the research area of the nature of the pet-human bond and can also be used to inform provision of veterinary services.

Previous studies in the USA and Australia have suggested that pets are more common in families who have children [16-26]. In contrast, a study of dog ownership in Germany found that the majority of the dog owners did not live with children younger than 18 years of age [27]. This project aimed to investigate factors associated with dog ownership in a semi-rural community using a doorstep interview questionnaire. The previous studies mentioned used telephone interview or mail questionnaire methods to sample a small proportion of a large study population. In contrast, this study attempted to doorstep interview all households in a defined geographic area to produce a detailed census of a single community. Whereas some other studies have combined dogs and cats as 'pets' for analysis, this study focused specifically on dogs; reasons for dog versus cat ownership are likely to differ as they have different ownership requirements.

Results

A total of 1142 households (89% of all council registered households) in the study area were contacted within five visits to the property. A further 136 households (11%) could not be contacted during five attempts, although 2% of the total properties were suspected to be unoccupied. Over half (53%) of the households were interviewed during the first round of visits. Of those households contacted and asked to participate, 1051 (92%) were fully interviewed, 24 (2%) part-interviewed (answered some but not all questions) and 67 (6%) were not willing to participate in the study. This gave an overall usable response rate of 84%.

Of the households contacted, 24% (266) were identified as dog owning (DO); only four of these DO households were not willing to be interviewed. Two hundred and one (77%) DO households owned one dog, 53 (20%) two dogs and eight (3%) three dogs (mean 1.3 dogs). Just over half (52%) of interviewed households owned a pet of some type. A variety of other pets were identified, cats (22% of households) being the most popular after dogs.

The most common reason given for not owning a dog by dog-free households (DF) was due to 'working or being out all day' (26% households) followed by 'not enough time for a dog' (15%). 'Do not like dogs' was reported less commonly (10%). Sixty-two percent of interviewees who did not own a dog had owned one in the past (including as a child). In such cases, the last dog had been owned a median of 10 years previously (interquartile range 5–24 years) with a maximum of 80 years previously. Households owning a dog reported 'companionship' (68%) and 'always had a dog' (42%) as their most common reasons for owning a dog.

When asked how often they came into physical contact with dogs (other than their own) DO reported increased contact compared to DF ($P < 0.001$): 'Everyday' (DO vs. DF; 49% vs. 14%) was clearly the most common answer from dog owners, whereas 'several times a week' (23% vs. 21%), 'once a week' (12% vs. 20%), or 'very rarely' (8% vs. 23%) were more common responses for those not owning a dog themselves (Figure 1). Interviewees were asked to suggest circumstances in which they come into contact with dogs other than their own; the most common answers were 'friends' (32%), 'walking' (31%) and 'family' (29%). DO respondents reported increased contact whilst walking (OR = 7.4, 95%CI 5.4–10.0) compared to DF respondents. Other effects of dog ownership included decreased contact with dogs through neighbours and increased contact through employment (OR = 0.6, 95%CI 0.4–1.00 and OR = 1.8, 95%CI 1.1–2.9 respectively).

Univariable analysis

Univariable analysis of DO versus DF (Table 1) identified presence of birds, fish and horse as significantly positively associated with DO status ($P < 0.05$). There was no evidence of an association between cat ownership and owning a dog.

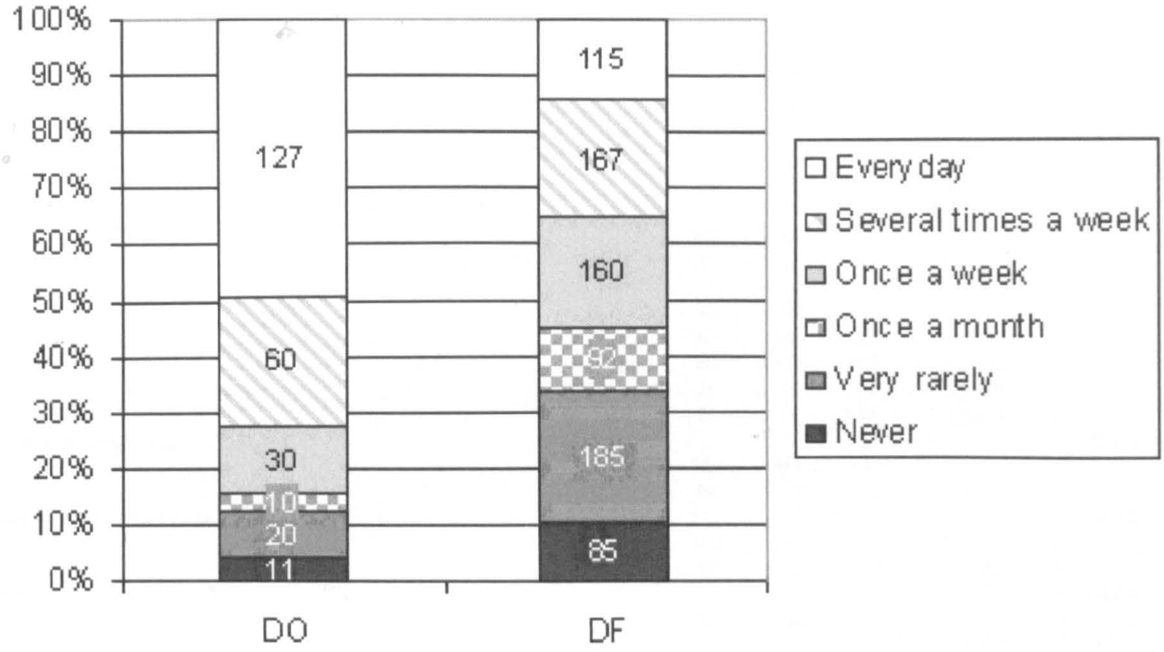


Figure 1
Reported contact with dogs (other than own dog) for Dog-owning (DO) and Dog-free (DF) households. The numbers indicate the number of respondents in each category. DO households were significantly more likely to have more frequent contact with dogs, compared to DF households ($P < 0.001$).

There was no evidence for a significant effect of either house type (flat, terrace, semi-detached and detached) or street type (cul-de-sac, through road) on household ownership of dogs ($P = 0.6$ and $P = 0.9$ respectively) in this area. There was an insufficient number of households with no garden or only a yard to compare with those with a garden for analysis of this factor. There was no evidence for a significant difference between DO and DF with respect to the amount that the garden was used for recreational purposes (such as eating, gardening, children playing) ($P = 0.98$). The most common response was 'often' (74%), possibly due to the study being conducted during summer months.

Two person households were most common in this population (37%). DO households were associated with a greater numbers of persons living in them (Table 1). The median number of persons per household was two for DF and three for DO, both with interquartile ranges 2–4. Mixed adult gender households were more likely to own a dog than single gender households. However this variable was associated with the number of people in the household ($P < 0.001$), with larger households more likely to have mixed genders and 1–2 person households more likely to be adult male or adult female only. Consequently, this variable was not used in multivariable analysis and presence/absence of an adult female and presence/absence of an adult male was preferred as an indicator of gender structure of the household. When considering presence of adults in the household, presence of an adult female was significantly associated with dog ownership.

DO and DF households were compared for presence and absence of particular age categories (Table 1). Presence of the age groups 6–19 yrs, 20–29 yrs and 30–59 yrs increased the odds of owning a dog. Households where a person of 60 yrs or older was present were less likely to own a dog. Certain occupations also influenced dog ownership (Table 1). The presence of Associate Professionals, Skilled Trades and Personal Service occupations were each positively associated with dog ownership. Presence of unemployed, permanently sick/disabled persons or full-time students (including children of school age) in the

Table 1: Univariable analysis of factors associated with dog ownership in a community in Cheshire, UK.

Variable	DO	DF	OR	95% CI	P-value
Birds					0.02
No	246	788	1		
Yes	16	24	2.1	1.1–4.1	
Fish					0.02
No	220	725	1		
Yes	42	87	1.6	1.1–2.4	
Horse					0.002*
No	253	807	1		
Yes	9	5	5.7	1.9–17.3	
N° Persons					<0.001
1	39	177	1		
2	85	303	1.3	0.8–1.9	
3	50	119	1.9	1.2–3.1	
4	56	160	1.6	1.0–2.5	
5+	31	41	3.4	1.9–6.1	
Presence of 6–19 yr olds					0.001
No	164	591	1		
Yes	96	209	1.7	1.2–2.2	
Presence of 20 to 29 yr olds					0.03
No	202	670	1		
Yes	58	130	1.5	1.1–2.1	
Presence of 30 to 59 yr olds					<0.001
No	61	286	1		
Yes	199	514	1.8	1.3–2.5	
Presence of 60 yrs or above					0.02
No	184	501	1		
Yes	76	299	0.7	0.5–0.9	
Presence of Associate professional and technical					0.04
No	211	691	1		
Yes	49	109	1.5	1.0–2.1	
Presence of Skilled trades					0.001
No	200	688	1		
Yes	60	112	1.8	1.3–2.6	
Presence of Personal service					<0.001
No	228	755	1		
Yes	32	45	2.4	1.5–3.8	
Presence of Unemployed					0.004*
No	252	795	1		
Yes	8	5	5.1	1.6–15.6	
Presence of Retired					0.002
No	193	511	1		
Yes	67	289	0.6	0.5–0.8	
Presence of Full-time student					0.01
No	163	570	1		
Yes	97	230	1.5	1.1–2.0	
Presence of adult female					0.004
No	12	84	1		
Yes	245	700	2.5	1.3–4.6	
Adult gender household					0.01
All male	12	84	1		
All female	40	144	1.9	1.00–3.9	
Mixed male/female	205	554	2.6	1.4–4.8	

* Fisher's exact test P-Value instead of Pearson Chi-Square
Significant findings on univariable analysis only reported.

household also increased the odds of dog ownership. Households with a retired person were less likely to own a dog.

Univariable analysis was also conducted on the dog owning households to compare single dog households with multiple dog households. Significant findings that increased the odds of being a multi-dog household compared to single included presence of a cat or bird (OR = 2.3, 95%CI 1.12–4.5 and OR = 4.8, 95%CI 1.7–13.5 respectively), or presence of at least one 20–29 yr old person (OR = 2.07, 95%CI 1.1–3.9).

Hierarchical cluster analysis of age and occupation
The external validity of groups identified by cluster analysis can be assessed by comparing the results of the cluster analysis with an external criterion [28]. The age groups and occupation groups identified using hierarchical cluster analysis (described in Methods and summarised in Table 2) were both significantly associated with dog ownership in univariable analysis (P = 0.001). These household age and occupation cluster groups were used in the multivariable modelling of dog ownership instead of individual variables for each age and occupation.

Multivariable analysis
The final model is presented in Table 3. None of the correlations between variables used in the final model were high (all <0.4). In the final model, ownership of a horse, age distribution groups, number of persons in the household, and presence of adult females were associated with the presence of one or more dogs in the household. The model appeared to fit the data well (Hosmer-Lemeshow statistic = 0.9). There were no significant two-way interactions between variables in the final model. Thirty-one (3%) households were not included in the final model due to missing data.

Discussion
This study on dog ownership and contact with dogs focused on a small geographic area and so care is required when generalising the results to other parts of the UK or other countries. However, the percentage of the population owning a pet was almost identical to the 53% reported previously for the UK in 2004 [15], supporting the suggestion that results gained from this study may be indicative of similar populations. Dog ownership was slightly higher (24% compared to 21%), and cat ownership lower (21% compared to 25%) in the current study compared to previous estimates, which may have been due to the semi-rural location being suitable for dog ownership. In a previous American study [21], the mean number of dogs owned by dog owning households was 1.5 compared to 1.3 found here, possibly reflecting the general increased level of dog ownership in America compared to the UK (38% households versus 21–24%) and the decreasing trends for dog ownership in recent years in the UK [15]. Comparing to Australia, a study of a randomly selected group of dog owners in Perth estimated 1.2 dogs per household, similar to our findings, but again a higher percentage of all households approached were identified as owning a pet (56%) or a dog (31%) [29].

This study attempted to survey all households in a defined geographic area. In contrast, the sampling methods used in other studies, such as recruiting from veterinary, insured, internet-using, telephone-owning or dog-lover/dog-hater populations, may have introduced bias not apparent in our study method. Previous information introducing the study (leaflets), combined with the local knowledge of and community links with the local veterinary teaching hospital, may have contributed to the very good response rate for the interviews.

Univariable analysis identified a number of variables potentially associated with dog ownership including: ownership of other animals (fish, birds, horse); the presence of older children (school age); an increased number of persons in the household; Associate professional, Skilled trades and Personal service occupations, Unemployed, Permanently sick/disabled, Full-time students; and adult females. In contrast, over 60s or retired persons had lower odds of owning a dog. This may be because of reduced mobility or not replacing a deceased pet because of a new pet's perceived longevity. On further (multivariable) analysis, ownership of a horse, age distribution and number of persons in the household and presence of adult females were found to be the most important factors. Ownership of fish and birds did not remain in the final model, whereas ownership of a horse was concluded to be associated. Possibly the commitment in regards to time, care and expenses given by horse owners to their horse(s) complement the required lifestyle when owning a dog. This finding has not been reported previously but may be due to the semi-rural nature of the study area.

This study supports the suggestion that pets, in this case dogs, are more common in families who have children [16-26]. However this effect may be modified by the age of the children. In our multivariable model, families with young children (in this case five years and under) were less likely to own dogs, and similar findings have been reported by others [18,22]. In contrast, Teclaw *et al.* [20] concluded (on the basis of univariable analysis only) that there was no significant effect of young children in the household on pet ownership. Amongst young children, dog ownership is a risk factor for zoonotic disease, for example campylobacteriosis [30], however reduced dog ownership by families with young children may lessen this effect.

Table 2: Description of groups from hierarchical cluster analysis of age and occupations.

Household age categories (χ^2 P = 0.001)	Description of households
1 (Over 60s)	Persons over 60 yrs present in all households, size mainly 1–2 persons.
2 (Families)	Very few households with under 5 yrs present, some with 6–19 yrs, many with 20–29 yrs, many with 30–59 yrs, size 1–5 persons.
3 (Families)	6–19 yrs present in all, 30–59 yrs in all, size 2–5 persons.
4 (Singles/couples adults)	30–59 yrs present in all households, size 1–4 persons (mostly 1–2).
5 (Young families)	Under 5 yrs present in all households, many 6–19 yrs, few 20–29 yrs, many 30–59 yrs, very few 60+yrs, size mainly 3–5 persons.
6 (Older families)	Very few households with 6–19 yrs present, few 20–29 yrs, many 30–59 yrs, all households 60+yrs present, size mainly 2–4 persons.

Household occupation categories (χ^2 P < 0.001)	Description of households
1 Sales	Sales occupation present in all households, other occupations mainly professionals, associate professionals, admin, process/plant, retired persons.
2 Skilled trade	Skilled trade occupation present in all households, other occupations mainly managers, professionals, sales persons.
3 Administrative and secretarial	Admin occupation present in all households, other occupations mainly managers, associate professionals, skilled, retired persons.
4 Retired	Retired occupation present in all households, no other occupations present.
5 Personal service	Personal service occupation present in all households, other occupations mainly managers, associate professionals, admin, skilled trades, sales, process/plant and retired persons.
6 Associate professionals	Associate professional occupation present in all households, other occupations mainly managers, professionals, skilled trade persons.
7 Process/plant and elementary.	Process plant and elementary occupation present, other occupations mainly associate professionals, admin, skilled trade persons.
8 Professional	Professional occupation present in all households, also other occupations mainly admin and retired persons.
9 Managers and senior officials	Manager occupation present in all households, other occupations mainly professional persons.

Key to occupations: Manager and senior officials (managers), Professional occupations (professionals), Associate professional and technical occupations (associate professionals), Administrative and secretarial occupations (Admin), Skilled trades occupations (skilled), Personal service occupations (personal service), Sales and customer service occupations (sales), Process, plant and machine operatives (process/plant), Elementary occupations (elementary).

Several theories have been proposed to account for potential interactions between pet ownership and the presence of children in a household [5,18,31]. Our finding that dogs are often owned by households with older children could be explained if children in the older age groups had encouraged their parents to acquire a dog, and/or the parents felt that that ownership would benefit the children [18]. Alternatively, some parents may have acquired dogs as surrogate dependents [5] as their children grew up and became less receptive to physical contact and being fussed over.

In our study there was no significant effect of housing type, whereas previous work has suggested that pet owners are more likely to live in single-family dwellings and larger houses [16,17]. Such differences between studies may reflect real differences in the study population, or may be due to the fact that we were considering only dog ownership compared to general pet ownership, and/or insufficient power to detect a difference in a small and relatively homogeneous study area.

Variations in pet ownership with annual household income level [16-18], [20-23] are possibly comparable to the variations in occupations found on univariable analysis in this study. Dog ownership was associated with higher household incomes in some American studies [16,17,20,21,23]. However, the occupations indicated by our findings as being associated with dog ownership (Associate professional and technical, Skilled trade and Personal service) are not ones that would necessarily be expected to receive high incomes (for example Managers and senior officials). The role of occupation or income in dog ownership is likely to be intertwined with other factors and may be not as important as seems; this is supported by the fact that it was not significant in our final multivariable model. Similarly in another American study, stratification by household characteristics and life

Table 3: Multivariable logistic regression model of factors associated with dog ownership in a community in Cheshire (n = 1044).

Variable	Coef	SE	OR	95% CI	P-value
Horse					**0.005**
No	0		1		
Yes	1.6	0.6	5.1	1.7–15.5	
Number of persons					**0.06**
1	0		1		
2	-0.1	0.3	0.9	0.5–1.5	
3	0.3	0.4	1.3	0.6–2.8	
4	0.1	0.4	1.1	0.5–2.4	
5+	10.9	0.4	2.4	1.0–5.7	
Age group (from cluster analysis)					**0.04**
5 Young families	0		1		
1 Over 60's	0.4	0.4	1.5	0.7–3.5	
2 Families	0.8	0.3	2.3	1.2–4.3	
3 Families	0.8	0.3	2.2	1.2–4.0	
4 Singles/couples adults	0.8	0.4	2.3	1.0–5.2	
6 Older families	0.9	0.4	2.5	1.1–5.5	
Presence of adult female					**0.03**
No	0		1		
Yes	0.8	0.4	2.2	1.1–4.6	

groups (similar to our age cluster groupings) appeared to account for the effects of education and household income on dog ownership [22]. A study in Ontario also concluded that socioeconomic status was not unconditionally associated with pet ownership after multivariable analysis [18].

The finding of presence of an adult female in the household associated with dog ownership may be due to differing attitudes to pets between the sexes. Tower and Nakota (2006) investigated the relationships between depression and pet (dogs and cats) ownership in the USA using an internet survey [26]. They found that for men: being married, living with children, being Midwestern and non-urban increased odds of living with a pet, and for women: being white, having a high income, living with children and living in a rural setting increased odds of pet ownership. They concluded that unmarried women living with a pet had the lowest depressive symptoms and unmarried men living with a pet the highest, leading them to suggest that single men may be burdened by pet ownership, whereas single women may benefit from pet companionship, but when married the pet may bring additional stress to the woman already possibly nurturing a family [26]. Our study supports the suggestion that there are underlying differences between the sexes with regard to pet ownership.

The most common reasons for dog ownership in this study (mainly "companionship") support previous research [4,9,18,31]. The elderly are a group that may be most isolated and would benefit from this companionship, as well as having something to care for and exercise [4], and yet they are less likely to own dogs compared to those people living in large families, with the most companionship already.

In our study, the reasons given for non-ownership were similar to previous findings [18] in that 'not enough time' scored highly and 'health reasons' or 'don't like dogs' scored lower, but the most common reason given in our study was 'working or being out all day' rather than 'problem when I go away' or 'housing limitations' as reported previously [18,32]. This could be due to the nature of our study area, or the use of boarding kennels possibly being a more commonplace occurrence in recent years. It must be noted that the categories given in this study were slightly different than those in previous studies. The data suggests that some of those without dogs had made a conscious decision not to own a dog (e.g. they are out all day) even though they may like to. Sixty-two percent had owned dogs in the past or lived with them at some point in their lifetime, reflecting the fact that the dog-owning population is dynamic rather than fixed. Therefore, as a person's circumstances may change, so may their risk of zoonotic disease through dog ownership.

No overall significant effect on dog ownership of cat ownership was identified. However, further analysis suggested that this relationship is more complex than first appears, as multi-dog households were significantly more likely to own a cat or bird than single dog households. It may be that some households generally have more pets, including multiple dogs, cats and birds. Interestingly multi-dog households were also more likely to contain 20–29 yr olds, possibly because young adults have the time and energy to own multiple dogs.

Clearly in this study, dog owners not only have extensive contact with their own dog, but also have increased contact with other dogs compared to those without dogs. There is a possibility that DO respondents had a greater awareness of dogs in general and this led to recall bias. The increased contact seems to be mainly through walking. It could not be determined if dog owners actually walk more or are more likely to offer walking as a reason for contacting dogs. People who own dogs may also be more likely to walk in areas frequented by other dogs, as these areas provide for socialisation of both dogs and owners, and may provide off-lead play areas which are free from hazards. Some dog owners stated employment as a reason for contacting dogs although only a small number actually worked in dog-related professions. The decreased likelihood for dog owners to report contact with a neighbour's dog may be due to recall bias. A dog owner questioned about contact may immediately identify 'walking' as a reason, whereas for non-dog owners, a neighbour's dog may be more likely to be recalled (especially if not liked).

The results of this study may be of use in behavioural research, for provision of veterinary and other services and to inform strategies for quantifying health benefits and risks associated with dog ownership. Detailed studies on the type of dog-human and dog-dog interactions that occur in the pet dog population are now needed.

Conclusion

Some households are more likely to own a dog than others and this is associated with a number of factors, including number of people, ages of those people, an adult female in the household and ownership of a horse. Other pets, such as cats or birds, appear to be associated with multiple dog households. Dog owners also have increased contact with dogs in general (other than their own) compared with those not owning a dog, and this contact seems to be mainly through walking.

Methods

A community of 1278 houses in Cheshire, UK, was identified as the study area. This area is on the edge of a town and was selected because it: is reasonably well defined by natural boundaries; has a mixture of medium and low-density housing; has public amenities including parks; and is near to sports fields, a wildlife reserve and agricultural land. Data were gathered using a questionnaire containing multiple choice and open-ended questions, administered during face-to-face doorstep interviews. The questionnaire had been thoroughly pre-tested, revised and piloted on approximately 100 households in a nearby area. It was designed using a high-accuracy, high-throughput automated content capture system, TELE*form* v9.1 (Verity Software, 2005), aiding design in a professional format and facilitating rapid and accurate data entry.

Each household was identified by address and visited up to five times over a five week period (July-August 2005). The time of visiting each house varied between 2 pm-8 pm weekdays and 10 am-5 pm Saturdays in an attempt to increase the possibility of interview, as identified in a pilot study. A week prior to commencement of the interviews all households were sent a leaflet to inform them of the study. Persons willing and over 16 yrs of age were interviewed on the door-step by trained interviewers following specified procedures to minimise interviewer bias. They were asked about their pets, possible reasons for not owning a dog, contact with dogs and household demographics. This included for each individual household member: gender, age category and job description or other reasons for not being in employment. Job descriptions were later categorised if possible into general types based on Standard Occupational Classification 2000 [33]. Interviewees could terminate the interview at any time or not disclose certain information if they wished and they were assured that the information would remain confidential. The interview took approximately two minutes.

Data were managed in a Microsoft Access Database and analysed using Microsoft Excel (Microsoft Corporation, 2003) Minitab (Minitab release 14.2, Minitab Inc, 2005) and SPSS (SPSS 13.0 for Windows, SPSS Inc, 2004). Dog-owning (DO) and dog-free (DF) household responses to each question were initially compared using chi-squared analysis, Fisher's exact test and univariable logistic regression. Similar methods were used to compare single with multiple dog households. When considering data collected at the level of the individual household member, the analysis was done at the household level considering presence or absence of each category.

Development of a multivariable model of dog ownership was complex due to correlation between many of the demographic variables measured at the level of the household member (age and occupation), rather than the household level (at which the outcome was measured). Because of this, hierarchical cluster analysis was used to classify households into categories by age distribution and separately into occupation categories (excluding full-time students, unemployed, looking after home/family, or permanently sick/disabled), using the Ward method for distance measurement and based on presence or absence of appropriate categories. This was an iterative process until satisfactory division of clusters was reached that approximated some real-life meaning. The age (n = 6) and occupation (n = 9) distribution cluster groupings were used to build a multivariable model of dog ownership by backward elimination. Variables and interaction terms remained in the model if they were significant in the model ($P < 0.05$) or if removal resulted in substantial change to the effect of other variables (10% or greater). The fit of the model was assessed using the Hosmer-Lemeshow statistic.

Authors' contributions

CW designed the study, carried out the data collection, performed the data analysis and drafted the manuscript. RMC and GP assisted with data collection and analysis. RMC, RMG, GP, SD and JWSB conceived of the study and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We thank DEFRA for funding the research, the other interviewers (Robert Currie, Kathryn Lloyd, Lisa Nicolson and Claire Scantlebury) for their hard work, and the people who participated in the study.

References

1. Headey B: **Pet ownership: good for health?** *Medical Journal Of Australia* 2003, **179(9)**:460-461.
2. McNicholas J, Gilbey A, Rennie A, Ahmedzai S, Dono JA, Ormerod E: **Pet ownership and human health: a brief review of evidence and issues.** *BMJ* 2005, **331(7527)**:1252-1254.
3. Friedmann E: **The role of pets in enhancing human well-being: physiological effects.** In *The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership* Edited by: Robinson I. Oxford , Elsevier Science Ltd; 1995:33-53.
4. Katcher AH, Friedmann E: **Potential health value of pet ownership.** *California Veterinarian* 1982, **36**:9-13.
5. Katcher AH: **Interactions between people and their pets: form and function.** In *Interrelations between people and pets* Edited by: Fogle B. Springfield , Charles C. Thomas; 1981:41-67.
6. Heady B, Grabka M, Kelley J, Reddy P, Tseng Y: **Pet ownership is good for your health and saves public expenditure too: Australian and German longitudinal evidence.** *Australian Social Monitor* 2002, **4**:93-99.
7. Friedmann E, Katcher AH, Lynch JJ, Thomas SA: **Animal companions and one-year survival of patients after discharge from a coronary-care unit.** *Public Health Rep* 1980, **95(4)**:307-312.
8. Endenburg N, Baarda B: **The role of pets in enhancing human well-being: effects on child development.** In *The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership* Edited by: Robinson I. Oxford , Elsevier Science Ltd; 1995:7-17.
9. Brodie JD: **Health benefits of owning pet animals.** *Veterinary Record* 1981, **109(10)**:197-199.
10. Hart LA: **The role of pets in enhancing human well-being: effects for older people.** In *The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership* Edited by: Robinson I. Oxford , Elsevier Science Ltd; 1995:19-31.
11. Burch MR, Bustad LK, Duncan SL, Frederickson M, Tebay J: **The role of pets in therapeutic programs.** In *The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership* Edited by: Robinson I. Oxford , Elsevier Science Ltd; 1995:55-69.
12. Greene CE, Levy JK: **Immunocompromised people and shared human and animal infections: zoonoses, sapronoses and anthroponoses.** In *Infectious Diseases of the Dog and Cat* Third edition. Edited by: Greene CE. St. Louis, Missouri , Saunders Elsevier; 2006:1051-1068.
13. Robinson RA, Pugh RN: **Dogs, zoonoses and immunosuppression.** *J R Soc Promot Health* 2002, **122(2)**:95-98.
14. Egerton JR: **Pets And Zoonoses.** *Med J Aust* 1982, **2(7)**:311-311.
15. PFMA: **Pet Food Manufacturers Association. Pet ownership trends.** [http://www.pfma.com/public/petownership.htm].
16. Franti CE, Kraus JF: **Aspects of pet ownership in Yolo-County California.** *J Am Vet Med Assoc* 1974, **164(2)**:166-171.
17. Franti CE, Kraus JF, Borhani NO, Johnson SL, Tucker SD: **Pet ownership in rural Northern California (El-Dorado County).** *J Am Vet Med Assoc* 1980, **176(2)**:143-149.
18. Leslie BE, Meek AH, Kawash GF, McKeown DB: **An epidemiologic investigation of pet ownership in Ontario.** *Canadian Veterinary Journal-Revue Veterinaire Canadienne* 1994, **35(4)**:218-222.
19. McHarg M, Baldock C, Headey B, Robinson A: **National people and pets survey.** Australia, Urban Animal Management Coalition; 1995.
20. Teclaw R, Mendlein J, Garbe P, Mariolis P: **Characteristics of pet populations and households in the Purdue-Comparative-Oncology-Program Catchment-Area, 1988.** *J Am Vet Med Assoc* 1992, **201(11)**:1725-1729.
21. Troutman CM: **Veterinary services market for companion animals.** *J Am Vet Med Assoc* 1988, **193**:920-922, 1056-1058, 1217-1219.
22. Wise JK, Kushman JE: **Pet ownership by life group.** *J Am Vet Med Assoc* 1984, **185(6)**:687-690.
23. Wise JK, Yang JJ: **Veterinary Service Market For Companion Animals, 1992 .1. Companion Animal Ownership And Demographics.** *J Am Vet Med Assoc* 1992, **201(7)**:990-992.
24. Beck AM, Meyers NM: **Health enhancement and companion animal ownership.** *Annu Rev Public Health* 1996, **17**:247-257.
25. Messent PR: **Correlates and effects of pet ownership.** In *The pet connection: Its influence on our health and quality of life* Edited by: Anderson RK, Hart BL, Hart LA. Minneapolis , Center to study Human-Animal Relationships and Environments, University of Minnesota.; 1984:331-340.
26. Tower RB, Nokota M: **Pet companionship and depression: results from a United States Internet sample.** *Anthrozoos* 2006, **19(1)**:50-64.
27. Brand U: **Comparative survey of dog owners in Berlin and Brandenburg, Germany.** *Tierarztl Umsch* 2002, **57(6)**:309-316.
28. Sharma S: **Cluster Analysis.** In *Applied Multivariate Techniques* John Wiled and Sons Inc; 1996:185-237.
29. Robertson ID, Shaw SE, Clark WT: **The use of health management practices by a randomly selected group of dog owners in Perth.** *Aust Vet Pract* 1991, **21(3)**:126-130.
30. Tenkate TD, Stafford RJ: **Risk factors for campylobacter infection in infants and young children: a matched case-control study.** *Epidemiol Infect* 2001, **127**:399-4040.
31. Feldmann BM: **Why people own pets - Pet owner psychology and the deliquent owner.** *Animal Regulation Studies* 1997, **1**:87-94.
32. Selby LA, Rhoades JD, Irvin JA, Carey GE, Wade RG: **Values and limitations of pet ownership.** *J Am Vet Med Assoc* 1980, **176(11)**:1274-1276.
33. **Standard Occupational Classification** [http://www.statistics.gov.uk/nsbase/methods_quality/ns_sec/soc2000.asp#vol1]

Dog-human and dog-dog interactions of 260 dog-owning households in a community in Cheshire

C. WESTGARTH, G. L. PINCHBECK, J. W. S. BRADSHAW, S. DAWSON, R. M. GASKELL, R. M. CHRISTLEY

This study investigated the nature and frequency of the contacts that occur between dogs, and between dogs and people, by means of a questionnaire survey of 260 dog-owning households in a community in Cheshire, UK. The contacts were highly variable and were affected by the size, sex and age of the dog, individual dog behaviours, human behaviours and human preferences in the management of the dog. A number of situations were identified that may be important in relation to zoonoses, including sleeping areas, playing behaviours, greeting behaviours, food sources, walking, disposal of faeces, veterinary preventive treatment and general hygiene.

THERE are approximately 6·5 million dogs owned in the UK (Pet Food Manufacturers Association [PFMA] 2004), which equates to approximately one dog for every nine people and every four households (Office for National Statistics 2007). Dog ownership is associated with many benefits for people, including companionship and physiological and psychological health (Katcher 1981, Katcher and Friedmann 1982, Friedmann 1995, Headey 2003, McNicholas and others 2005), but there are also negative aspects, recently highlighted by Jackson (2005), including dog bites, public nuisance, and risks to public health from zoonoses. At least 30 to 40 diseases of companion animals are transmissible to human beings (Greene and Levy 2006), including parasitic, bacterial, fungal and viral diseases (Geffray and Paris 2001); examples in dogs in the UK include *Campylobacter* and *Salmonella* species, *Toxocara canis* (Tan 1997, Greene and Levy 2006) and meticillin-resistant *Staphylococcus aureus* (MRSA) (Cefai and others 1994, Greene and Levy 2006). In Australia, the ownership of pet puppies has been reported to be a risk factor in campylobacteriosis in young children (Tenkate and Stafford 2001), and exposure to diarrhoeic animals has been associated with a threefold increase in the risk of *Campylobacter jejuni/Campylobacter coli* enteritis in human beings (Saeed and others 1993).

Little is known about the nature and frequency of contacts between pet dogs and their owners or other people, but in order to assess the risk of disease transmission from pets it is important that such factors are evaluated (Wieland and others 2005). The nature of the pathogen and its mode of transmission is also important. People may be exposed to zoonoses either by direct contact, through biting, licking, scratching, urine spray, sneezing or coughing, or handling the dog or its faeces or reproductive discharges, or by indirect contact through contaminated bedding, food, water, or bites from an arthropod vector (Robinson and Pugh 2002). Activities involving close contact between dogs and people include sleeping, playing, eating, greeting, the disposal of faeces, and general physical contact through tokens of affection such as cuddling and stroking.

Similarly, little is known about the contacts between dogs that could transmit an infection through a population, for example, during interactions between dogs while they are out walking or through indirect contact during the investigation of other dogs' excreta. Bradshaw and Lea (1992) characterised the sequences of behaviour that occur during interactions between dogs in popular walking areas, but did not measure the frequency of the interactions, an important factor affecting the risk of transmitting a pathogen. Opportunities for the transmission of pathogens between dogs will be affected by human preferences, such as the frequency of walks and the times the dog is allowed off the lead, in addition to the types of behaviour of individual dogs.

A combination of human and dog behaviours determines where a dog goes and what it does. Studying interactions is not only of zoonotic importance, but of behavioural, welfare, psychological and social interest. The aim of this study was to investigate and quantify the direct and indirect contacts between dogs, and between dogs and people, in households in a community in Cheshire. The contacts that were considered likely to be associated with a risk of the transmission of pathogens of zoonotic importance were a particular focus of the study.

MATERIALS AND METHODS

In a doorstep survey of 1278 households in a community in Cheshire (Westgarth and others 2007), the owners of 327 dogs were identified and recruited into the study. The area and its surroundings include medium- and low-density housing, public amenities such as parks, sports fields and a wildlife reserve, and agricultural land. Basic demographic information was collected for each dog when it was recruited. The 260 dog-owning households were asked to complete a questionnaire, containing multiple-choice and open-ended questions, which had been pre-tested, revised and then piloted on 12 dog-owning households in a nearby area. The questionnaire was designed using an automated content-capture system (TELE*form* version 9.1; Verity Software) and is available from the authors on request. The questions were chosen specifically to investigate behaviours with the potential to transmit zoonotic pathogens, and covered a wide variety of topics: where the dog sleeps and is allowed access, the games it plays, its health, diet, walk frequency, and behaviour when greeting people and other dogs. The questionnaires were returned between July and October 2005. Households that had not returned their questionnaire after two weeks were sent a reminder postcard, and if they had still not returned it after another four to six weeks they were sent another copy of the questionnaire. Incentives to participate included money-off vouchers for dog food and a local boarding kennels, which were provided after the questionnaire had been returned.

The data were managed in a Microsoft Access database and analysed using Minitab release 14.2, SPSS 13.0 for Windows, and Microsoft Excel. Chi-squared tests were used to investigate associations between answers to questions with factors such as the sex and size of the dog. The frequency of many of the variables was estimated as either 'never', 'rarely', 'sometimes' or 'often'. This ordinal outcome was assessed using ordinal logis-

Veterinary Record (2008) 162, 436-442

C. Westgarth, BSc,
G. L. Pinchbeck, BVSc, CertES, PhD, DipEVCPH, MRCVS,
S. Dawson, BVMS, PhD, MRCVS,
R. M. Christley, BVSc, DipVetClinStud, MVetClinStud, PhD, DipEVCPH, MRCVS,
Department of Veterinary Clinical Science,
R. M. Gaskell, BVSc, PhD, MRCVS,
Department of Veterinary Pathology, University of Liverpool, Leahurst, Neston, Cheshire CH64 7TE
J. W. S. Bradshaw, BA, PhD,
Anthrozoology Institute, Department of Clinical Veterinary Science, University of Bristol, Langford House, Langford, North Somerset BS40 5DU

TABLE 1: Significant associations between the frequency of contact behaviours and the size of the dog reported for 279 dogs in Cheshire

Covariate	Size of dog	Never	Rarely	Sometimes	Often	P
		Frequency (number [%])				
Lies on furniture	Toy/small	17 (18)	10 (11)	29 (31)	37 (40)	<0·001
	Medium	37 (39)	9 (10)	22 (23)	26 (28)	
	Large/giant	45 (58)	8 (10)	16 (21)	8 (10)	
Lies on person's lap	Toy/small	9 (10)	13 (14)	26 (29)	43 (47)	<0·001
	Medium	33 (36)	21 (23)	24 (26)	13 (14)	
	Large/giant	59 (72)	9 (11)	12 (15)	2 (2)	
Jumps up at household members	Toy/small	3 (3)	9 (10)	32 (34)	49 (53)	<0·001
	Medium	17 (18)	11 (12)	29 (32)	35 (38)	
	Large/giant	22 (28)	19 (24)	23 (29)	14 (18)	
Jumps up at visitors	Toy/small	7 (8)	11 (12)	33 (37)	39 (43)	<0·001
	Medium	19 (21)	14 (15)	30 (33)	28 (31)	
	Large/giant	33 (41)	13 (16)	21 (26)	13 (16)	
Fetch games (missing data assumed as 'never')	Toy/small	24 (24)	10 (10)	21 (21)	44 (44)	0·01*
	Medium	10 (11)	5 (5)	24 (25)	56 (59)	
	Large/giant	8 (10)	6 (7)	31 (37)	39 (46)	
Tug-of-war games	Toy/small	9 (10)	7 (8)	35 (40)	36 (41)	0·02
	Medium	16 (18)	18 (20)	24 (27)	31 (35)	
	Large/giant	21 (25)	10 (12)	28 (34)	24 (29)	
Frequency of walks		Once per week	1 to several per week	1 to 2 per day	3+ per day	
	Toy/small	5 (5)	27 (27)	55 (56)	12 (12)	0·04
	Medium	1 (1)	14 (15)	63 (66)	17 (18)	
	Large/giant	0 (0)	14 (17)	54 (64)	16 (19)	

* P=0·08 if missing data removed rather than assumed to be 'never'

tic regression analysis for the continuous variable age, with the lowest category as 'never'. The association between the ordinal variables 'likely to greet dogs' and 'likely to greet people' was tested using the Gamma statistic (Siegal and Castellan 1988). Questions about the respondents' views on the positioning and emptying of dog-waste bins in the area were used to introduce the subject of picking up faeces. In the households in which one main person performed the dog duties, this person would have been asked to complete the questionnaire, and the responses to the questions on picking up faeces were compared for male and female owners by chi-squared tests.

RESULTS

Of the dogs initially recruited into the study, 78 per cent were of a named breed, as opposed to crossbreeds or mixed breeds. Gundogs were the most popular UK Kennel Club category (25 per cent), followed by mixed or crossbreeds (23 per cent). Labradors were the most popular of the individual breeds (15 per cent), followed by Jack Russell terriers (13 per cent). Approximately equal numbers of the dogs were small, medium or large, with very few toy or giant breeds. The mean (sd) approximate or known age (317 dogs) was 6·5 (3·9) years, with a maximum of 19 years. There were 173 females and 154 males. Fifty-three per cent of males had been neutered, compared with 73 per cent of females; the odds of a female being neutered was 2·3 (95 per cent confidence interval [CI] 1·4 to 3·7) times greater than for a male. Fifty-nine per cent of the dogs had been acquired by the current owner from the person who bred the dog.

Completed questionnaires were returned for 279 (85 per cent) of the 327 dogs recruited into the study. Twelve per cent of households with either one or two dogs did not respond, compared with 43 per cent of three-dog households.

Dog-human and dog-dog contacts

Seventy-nine per cent of the dogs were fed in the kitchen. The most popular food was dry complete commercial dog food, though one dog was fed raw meat as part of its main diet. Eighty-three per cent of the dogs were never fed raw meat. Commercial dog treats were fed to 85 per cent of the dogs 'sometimes' or 'often'. Human food titbits were fed to dogs 'sometimes' or 'often' from the hand (62 per cent), in the dog's bowl (69 per cent), straight from the plate (11 per cent) or off the floor (37 per cent). Six per cent of the dogs 'sometimes' or 'often' found and ate raw carcases, 25 per cent rolled in them, and 6 per cent 'sometimes' found and ate dog faeces. Eighty-four per cent of the dogs had visited a veterinary surgeon in the past year, 4 per cent because of vomiting and/or diarrhoea. Sixty-two per cent of the dogs had been vaccinated in the past year. Flea treatment had been given in the past three months to 53 per cent, and worming treatment to 58 per cent of the dogs.

The most common sleeping place for the dog was in the kitchen (42 per cent 'always' or 'often'); 19 per cent slept on the bedroom floor 'always' or 'often' and 14 per cent on a human bed. During the day, the living area was the most popular place for the dogs to rest, with 60 per cent being there 'always' or 'often'. Only 4 per cent of the dogs slept outside 'always' or 'often', but 29 per cent spent time there during the day 'always' or 'often'. When the owner was at home 56 per cent of the dogs were allowed anywhere in the house, but when the dog was on its own it was common to be restricted to the kitchen (24 per cent) rather than allowed everywhere (20 per cent). Fifty-two per cent of the dogs were reported to lie on furniture and 45 per cent on a person's lap 'sometimes' or 'often'. Smaller dogs were significantly more likely to lie on furniture or on a person's lap (Table 1) and younger dogs were also more likely to lie on a person's lap (Table 2).

When interacting with household members, sniffing or nudging with the nose, jumping up, and licking hands were commonly reported to occur 'sometimes' or 'often' (Fig 1). The neutered females tended to show sniffing or nudging behaviour more often, but the group sizes were small (Table 3). Smaller dogs were reported to jump up more often than larger dogs (Table 1). Ordinal logistic regression identified jumping up, licking faces and licking the hands of household members as significantly more common in younger dogs (Table 2).

The most common type of game played with the dog was to fetch a ball or other object (77 per cent 'sometimes' or 'often'). Larger dogs were reported to play fetch more often than smaller dogs (Table 1), although the difference was significant only if the respondents not reporting playing fetch but reporting playing games other than fetch were categorised as 'never' for fetch. There were significant differences in the frequency of fetch games by sex/neuter status (Table 3), with entire females reportedly playing more fetch games. Tug-of-war was more likely to be played by smaller dogs than larger dogs (Table 1). Ordinal logistic regression showed that the younger dogs played all the games more frequently (Table 2).

The most common frequency reported for adult visitors to the house was several times a week (42 per cent), whereas for children it was once a week (20 per cent) or once every several months (21 per cent), but 23 per cent of the households had adult visitors every day and 12 per cent had child visitors every day. The most common behaviours reported when greeting visitors were sniffing or nudging with the nose, jumping up and barking (Fig 1). Smaller dogs were reported to jump up at visitors more often than larger dogs (Table 1), and there was some evidence that entire dogs jumped up more often than neutered dogs (Table 3). The age of the dog was also significantly associated with whether they were reported to jump up at visitors or lick visitors' faces (Table 2), with younger dogs more likely to exhibit these behaviours. Ten per cent of the dogs were reported to growl 'sometimes' or 'often' at visitors, compared with 6 per cent that growled at household members.

TABLE 2: Significant associations between the frequency of contact behaviours and the age of the dog (identified by using ordinal logistic regression) reported for 279 dogs in Cheshire

Covariate	Frequency (mean [sd] approximate age [years]) Never	Rarely	Sometimes	Often	OR (95% CI)*	P
Lies on person's lap	7·6 (4·1)	7·3 (3·6)	6·1 (3·8)	5·4 (3·6)	1·1 (1·1-1·2)	<0·001
Jumps up at household members	8·2 (3·3)	8·2 (3·4)	6·3 (4·1)	5·4 (3·8)	1·2 (1·1-1·2)	<0·001
Jumps up at visitors	8·7 (3·5)	8·6 (3·6)	6·2 (3·7)	4·4 (3·3)	1·3 (1·2-1·3)	<0·001
Licks faces of household members	8·0 (3·8)	6·4 (4·0)	6·4 (3·6)	4·5 (3·6)	1·2 (1·1-1·2)	<0·001
Licks faces of visitors	7·6 (3·8)	5·2 (3·8)	6·7 (3·9)	2·0 (2·0)	1·2 (1·1-1·3)	<0·001
Licks hands of household members	7·2 (3·4)	7·1 (4·2)	6·7 (4·0)	5·5 (4·1)	1·1 (1·0-1·1)	0·01
Fetch games	8·8 (3·6)	8·4 (3·9)	7·3 (3·8)	5·6 (3·7)	1·2 (1·1-1·3)	<0·001
Tug-of-war games	7·6 (3·8)	7·8 (3·4)	7·0 (4·1)	5·1 (3·5)	1·1 (1·1-1·2)	<0·001
Rough-and-tumble games	7·5 (4·0)	8·1 (3·8)	6·3 (3·5)	5·1 (4·0)	1·1 (1·1-1·2)	<0·001
Chase games	8·1 (3·7)	7·5 (4·3)	5·7 (3·5)	5·3 (3·8)	1·2 (1·1-1·2)	<0·001
Playful with other dogs	8·7 (3·9)	6·0 (3·5)	6·5 (3·8)	5·6 (3·6)	1·1 (1·1-1·2)	0·001
Ignores other dogs	6·0 (4·5)	6·6 (3·8)	6·9 (3·4)	7·9 (4·0)	0·9 (0·9-1·0)	0·03
Length of walk (minutes)	0-15	16-30	31-60	>60		
	8·6 (4·1)	7·0 (4·2)	6·2 (3·7)	6·5 (3·1)	1·1 (1·0-1·1)	0·04

* Odds ratios (ORs) are derived from ordinal logistic regression with 'never' as the lowest category; OR<1 indicates that as age increases the probability of being in the higher categories increases; OR>1 indicates that age increases the probability of being in the lower categories increases
CI Confidence interval

Dogs may make contact with other dogs and people when they are taken out of the house, on a walk or to other places. The most common situation reported was being taken to friends' or relatives' houses (23 per cent 'once a week or more' and 6 per cent 'every day'). Ninety-three per cent of the dogs never visited training classes, 67 per cent never visited boarding kennels, and 67 per cent never visited grooming parlours. Thirty-seven per cent of the owners had taken their dog on holiday with them in the UK in the past year, but only one owner had taken their dog elsewhere in Europe. Most of the dogs were estimated by their owner to meet and interact with three to five people per day outside the household (Fig 2), and they met significantly more people at weekends than on weekdays (P=0·001). This trend was also observed when estimating the number of other dogs met and interacted with per day, with one to two being most common for weekdays and three to five at weekends (P=0·01) (Fig 2). Seventy-six per cent of the dogs 'often' or 'sometimes' interacted physically with people, and 76 per cent interacted with other dogs outside the home, and there was evidence of 'gregarious dogs' that tended to interact with both dogs and people (Gamma statistic value 0·39, P<0·001). Common behaviours reported as occurring 'sometimes' or 'often' when interacting with another dog included being playful (59 per cent), sniffing (81 per cent), ignoring (42 per cent) and aggression (24 per cent). There were significant differences between the frequencies of reports of sniffing behaviour by male and female dogs (Table 3), but a chi-squared test for the trend was not significant. Younger dogs were more likely to play with other dogs and less likely to ignore other dogs (Table 2).

Eighty-three per cent of the dogs were confined to a secure area and never roamed unattended away from the premises, and only 1 per cent were reported to be allowed to roam freely, although this may be an underestimate owing to the sensitive nature of the question. Thirty-two per cent of the dogs were walked twice a day, and 30 per cent were walked once a day. Only 3 per cent were never walked or walked less than once a week, but these included some young puppies and old dogs. Large or medium-sized dogs were walked more often than smaller dogs (Table 1) (chi-squared test for trend P=0·001).

Six per cent of the dogs were never on a lead when walked, but 14 per cent were never allowed off the lead. Of the dogs allowed off the lead, 67 per cent were always kept within sight. Most owners walked their dogs for between 16 minutes and one hour each time, and younger dogs were more likely to be walked for longer periods than older dogs (Table 2). Approximately half of the dogs were walked at regular times each day, with 06.00 to 09.00 being most common, but 09.00 to 12.00, 15.00 to 18.00, and 18.00 to 21.00 were also common times. Seventy-five per cent of the owners walked their dogs in the countryside, and 64 per cent walked them on the beaches and marshes next to the Dee Estuary; 69 per cent of the owners walked their dogs regularly in the same places. Twenty-seven per cent of the owners never took their dogs for walks out of the local area (in the car or by public transport), but 6 per cent did this every day, ranging up to 21 per cent less than once a month. Thirty-eight per cent of the owners reported never walking their dogs with a group of friends and their dogs, but 3 per cent did this every day; however, 92 per cent of owners noticed seeing the same people and their dog(s) 'every day', 'often' or 'sometimes' while walking their dog.

Five per cent of the dogs were reported to urinate in the house and 4 per cent were reported to defecate 'sometimes' or 'often'. More of the owners did not answer the question about toileting in the house than the question about toileting in the garden or on walks, possibly owing to the sensitivity of the subject, and the rates of toileting in the house may therefore be underestimated. Sixty-two per cent of the owners removed faeces from the garden or yard every day, but 1 per cent never removed them and 3 per cent removed them less than once a week. Seventy per cent of the owners used plastic bags to dispose of faeces from the garden or yard, and 91 per cent did so when they were elsewhere or

TABLE 3: Significant associations between the frequency of contact behaviours and the sex of the dog reported for 279 dogs in Cheshire

Covariate	Sex	Frequency (number [%]) Never	Rarely	Sometimes	Often	P
Sniffs/nudges household members with nose	Entire male	2 (4)	1 (2)	19 (33)	35 (61)	–
	Neutered male	2 (3)	5 (7)	24 (34)	39 (56)	
	Entire female	0 (0)	4 (12)	14 (42)	15 (47)	
	Neutered female	3 (3)	4 (4)	22 (22)	73 (72)	
Fetch games	Entire male	7 (13)	9 (16)	19 (34)	21 (38)	0·04
	Neutered male	7 (10)	5 (7)	22 (31)	37 (52)	
	Entire female	2 (6)	0 (0)	5 (16)	25 (78)	
	Neutered female	11 (11)	6 (6)	30 (30)	53 (53)	
Jumps up at visitors	Entire	14 (16)	9 (10)	33 (38)	31 (36)	0·06
	Neutered	45 (27)	29 (17)	49 (29)	45 (27)	
Sniffs other dogs	Male	7 (5)	12 (9)	32 (25)	77 (60)	0·03
	Female	7 (5)	6 (5)	54 (41)	64 (49)	

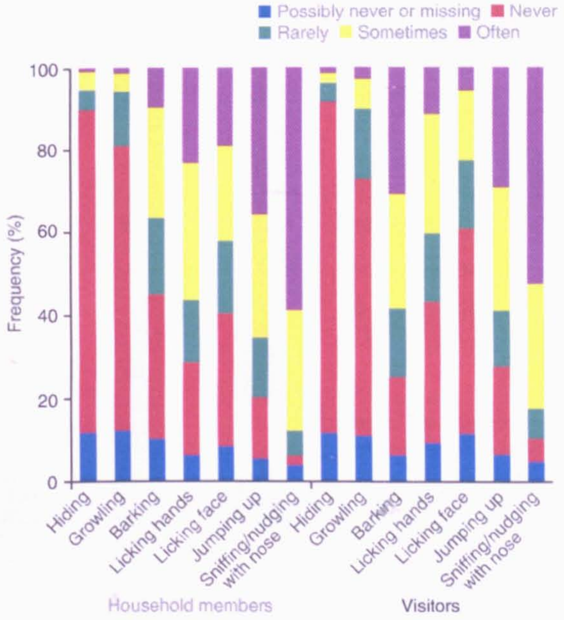


FIG 1: Frequency with which 279 dogs in Cheshire showed different types of behaviour when interacting with household members or greeting visitors

on a walk, but 42 per cent reported using a shovel in the garden or yard. Over 80 per cent of the respondents said that they always picked up any faeces passed by their dog while they were out walking in the street, park area or on a public path, but only just over 50 per cent did so when in the countryside (Fig 3). A significantly smaller proportion of male owners than females reported that they picked up faeces (Table 4). In a separate part of the questionnaire, the respondents were asked whether they washed their hands after picking up faeces, and 96 per cent said they did so 'always' or 'usually'; 85 per cent reported that they always or usually washed their hands before eating, but only 58 per cent did so after touching a dog.

DISCUSSION

This study investigated many of the common interactions between pet dogs and people that are relevant to dog welfare, the social benefits of owning a dog, and to the frequency of dog bites and public nuisance, particularly behaviours that may contribute to the transmission of zoonotic pathogens. Inside the house, a dog may be in close contact with household members and any visitors, and it may interact with people and other dogs while outside. The reported dog-dog and dog-human contacts were highly variable and affected by the type of household, the sex, size and age of the dog, the behaviour of individual dogs and people, and owner preferences in the management of the dog. The situations that may be of particular concern include sleeping areas, greeting, playing, food sources, disposal of faeces, general hygiene, walking and veterinary preventive treatment.

There was a preference for placing the dogs in the kitchen to sleep, be fed, and be confined when the owner was out of the house. This may have been partly for hygiene reasons and ease of cleaning up urine or faeces, and partly because it restricts the dog's access to the rest of the house and valuable household items. However, the kitchen is where the household's food is prepared, and this preference for placing dogs in the kitchen could be considered a risk for the transmission of zoonotic disease. Recent estimates suggest that 23 per cent of pet dogs in Norway (Sandberg and others 2002) and 41 per cent in Switzerland (Wieland and others 2005) carry *Campylobacter* species, and that 0·1 to 3·5 per cent of healthy dogs carry *Salmonella* species (Weber and others 1995, Fukata and others 2002, Hackett and Lappin 2003).

It has been suggested that pet food may be heavily contaminated with *Salmonella* species and may lead to the contamination of human food when dogs are fed in the kitchen (Christopher and others 1974, Pace and others 1977). However, these reports are old and the data may not apply to modern commercial pet foods. Most of the dogs were fed a commercial pet food, and were not deliberately fed raw meat, but a small number may have contacted raw meat by eating or rolling in carcases. Raw meat can be a source of many zoonotic pathogens such as *Campylobacter* and *Salmonella* species (LeJeune and Hancock 2001). A few of the dogs were reported to eat dog faeces, which could also be a source of infection. Eating faeces has previously been reported in only 0·2 per cent of dogs (Beaver 1994), but it is uncertain whether this figure represents only the dog's own faeces or included that of other dogs and animals. In the present study there was a considerably higher prevalence, but no reason could be identified for the difference.

Fourteen per cent of the dogs slept on a human bed 'always' or 'often', and approximately half of the dogs commonly lay on furniture or on a person's lap, behaviours that illustrate the often close physical and psychological nature of the relationship between dogs and people. It has been suggested that allowing such behaviours is likely to enhance the hierarchical status of the dog and may be associated with 'alpha' dog behavioural problems or aggression (Fisher 2001, Guy and others 2001), although Landsberg and others (2003) considered such behaviours unimportant. Substantial numbers of the owners reported such behaviours, but few of the dogs were said to growl at household members; however, this behaviour could have been under reported.

The close contact and sharing of beds or furniture could allow the transmission of zoonotic diseases or parasites such as fleas, especially by small and young dogs, which were more likely to lie on laps or furniture. In an ethological study in a small number of family homes, it was observed that small dogs were more likely to jump on to a person's lap than large dogs (Smith 1983). It has been reported that MRSA was transmitted to a person from an apparently healthy dog that routinely slept in a human bed and licked their faces (Manian 2003). It is not known how many healthy pet dogs in the UK are carriers of MRSA, but one small study of dogs in a veterinary referral hospital found a prevalence of 9 per cent, even though none of the dogs was being treated for MRSA infection (Loeffler and others 2005).

Common behaviours with household members and visitors such as sniffing and licking hands and faces could poten-

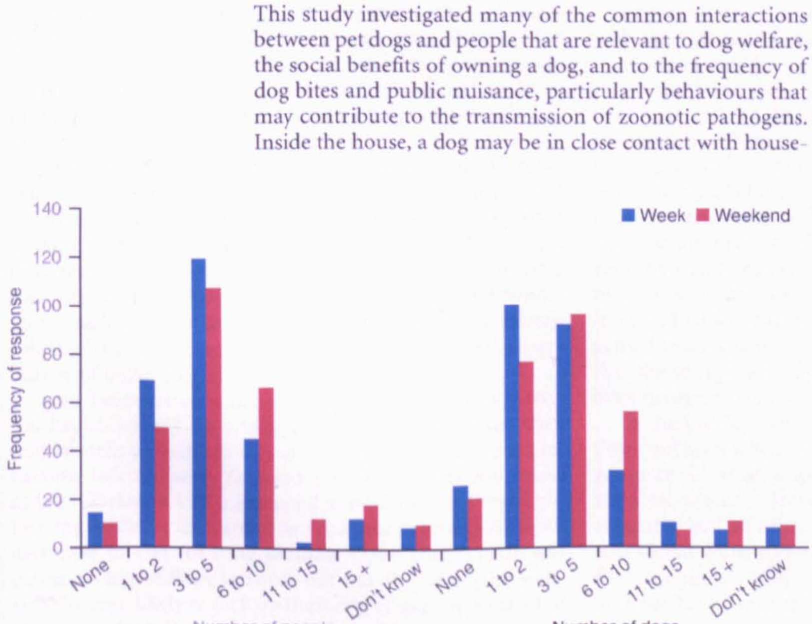


FIG 2: Estimates of the numbers of people and dogs met and interacted with daily during the week and at weekends by each of 279 dogs in Cheshire

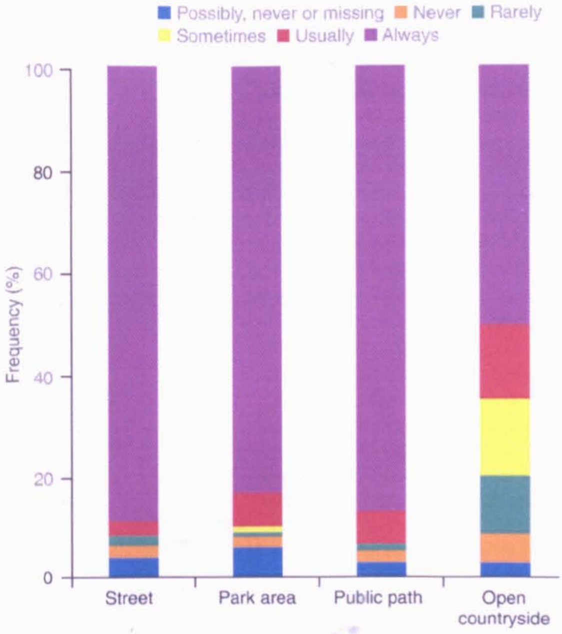


FIG 3: Frequencies with which 210 owners of dogs in Cheshire reported picking up their dog's faeces while on walks in different environments

TABLE 4: Frequency with which male and female owners of 279 dogs in Cheshire picked up their dog's faeces in different environments

Environment	Sex of owner	Frequency of picking up faeces (number [%]) Never/rarely/missing	Sometimes/usually/always	P*
Street	Male	7 (19)	30 (81)	0·11
	Female	6 (8)	73 (92)	
Park	Male	8 (22)	29 (78)	0·03
	Female	6 (8)	73 (92)	
Public path	Male	7 (18)	30 (81)	0·01
	Female	3 (4)	76 (96)	
Open countryside	Male	15 (41)	22 (59)	0·005
	Female	13 (16)	66 (84)	

* Fisher's exact P value

tially transfer pathogens. Such behaviours, which were more common in young dogs, are often attention-seeking/care-soliciting gestures (Scott and Fuller 1965) and indicate the strength of the social bond of dogs with people. Small dogs were also reported to jump up more often than large dogs, as has been reported by Smith (1983).

Many games were reportedly played with the dogs, and they may transfer saliva and potential pathogens to the hands, particularly with the popular game of 'fetch'. Rooney and others (2000) observed that medium-sized dogs were more likely to play games with their owners while out walking than large or small dogs, but they observed no such relationship in a different survey of owners on the games they played with their dogs. In the present study there were differences in the type of game played depending on the size of the dog, and the findings do not relate just to games played during walks. As in this study, fetch games have been reported to be played more often by large dogs while out walking (Messent 1983).

Another commonly reported activity that may transfer saliva was the giving of treats (commercial or human food titbits) from the hand. A small number of dogs were reported to eat directly from the plate. The majority of the owners reported that they always or usually washed their hands after touching a dog. Although the questionnaire was kept almost anonymous (traceable to household only by dog number), this is probably an overestimate owing to the owners' expectations of being judged by their answer.

Dog faeces are considered a nuisance as well as a potential health hazard. In addition to zoonotic bacteria, they may contain parasitic infections. For example, most puppies become infected with *Toxocara canis* in the first few weeks of life (Glickman 1990) and need to be dewormed regularly. Leaving faeces in the garden or yard may expose household members to risk for long periods. Open countryside was common dog-walking territory but was also where the owners were least likely to pick up their dog's faeces. Almost all of the respondents stated that they 'always' or 'usually' washed their hands after picking up faeces, but this would have been impossible in practice because most of the dogs commonly passed faeces while out walking. The majority of the respondents reported cleaning up after their dog; previous studies have observed 59 per cent of people cleaning up (Webley and Siviter 2000) but self-reporting gave much higher rates. In the present study the male owners appeared to be less likely to pick up after their dog, or alternatively they were more willing to admit leaving faeces.

Walking with a dog has been shown to facilitate social interactions, suggesting that there may be psychological, as well as physical, benefits to owners (Messent 1983). There was considerable variation in walking preferences, but a substantial number of the dogs were walked on regular routes at regular times of day, and could therefore have had repeated opportunities for contact with the same other dogs and people. This idea is supported by the fact that most of the owners reported that they noticed the same dogs and owners on their walks. More opportunities for contact at weekends than on weekdays were reported. The majority of the dogs remained in sight on walks when off the lead, suggesting that they stay fairly close. Bekoff and Meaney (1997) reported that dogs off the lead generally travelled less than 2 to 5 m off trail for less than one to two minutes, although this is likely to vary with the environment. Many of the owners reported regularly taking their dog in the car or by public transport to walk outside their immediate local area, providing opportunities for dogs from different areas to mix and increase the risk of transmitting disease further afield. Some dogs were regularly taken to friends' or relatives' houses where they could have interacted with other dogs and people.

Diseases may be transmitted through and persist in the dog population as a result of interactions between dogs while out walking. In this study, the younger dogs could be considered to have been more at risk than the older dogs because they more often came into close contact with other dogs through behaviours such as playfulness, and were less likely to ignore other dogs. There was some evidence that entire males may have been more likely to sniff other dogs. Bradshaw and Lea (1992) also observed that when two dogs met the most common interactions were inspections of the head and anogenital areas, with males investigating the anogenital area more frequently than females, and they suggested that the sex of the dogs (and possibly whether or not it had been neutered) may affect the type of interactions.

In the previous year before the study, the majority of the dogs had been taken to a veterinary surgeon; veterinary surgeons could be an important source of information about zoonotic diseases. However, not all of the dogs were taken regularly and so other sources of information need to be considered. Most commonly, the owners had acquired a dog from the person who bred it, and so the breeders could also be a source of information for new owners. Just over half of the dogs were reported to have been recently treated for gastrointestinal worms, and the same proportion for fleas. Effective flea and worm treatment is important both for the welfare of the dog and considering the close contacts observed with people.

This study attempted to survey all the households in a defined area, and it therefore provides a less biased view of dog ownership than other studies in which dogs were recruited either through veterinary practices or through calls for volunteers, who would be likely to be enthusiasts. Not all of the dogs had visited a veterinary surgeon in the past year and one-third of dogs had not been vaccinated; as a result, many dogs would have been missed if the dogs had been recruited from veterinary practices in the same area. Bias due to not contacting a household was minimised by visiting at several times of day and on several days of the week, ensuring good contact rates for the initial recruitment of the dogs. Leaflets providing information about the study and incentives to participate, combined with local knowledge and community links with the local veterinary teaching hospital, may have contributed to the good response rate for both the initial interviews and the return of the postal questionnaires. There may have been some bias due to the different interests of the people who completed and returned the questionnaire and those who did not, in particular owing to the use of incentives. A smaller proportion of households with three dogs completed and returned their questionnaires than households with one or two dogs; the extra work involved to complete the questionnaires for three dogs may have been a deterrent. The study was made in a small, semi-rural community, and the results may therefore not apply generally to the wider UK population. However, the percentage of the population owning a dog was similar (24 per cent) to the 21 per cent reported for the UK in 2004 (PFMA 2004), suggesting that the results may be representative of similar populations elsewhere.

The results provide previously unrecorded information about dog ownership that may be typical of many communities in the UK and may be relevant to a number of disciplines. In terms of human health, dogs are not thought to be a major cause of zoonotic infections in comparison with food, but they may be an important risk, particularly for immunocompromised people, the very young and the elderly. In an initial study of the characteristics of dog ownership in this community, it was found that certain types of households were more likely to own dogs than others (Westgarth and others 2007). In the present study, several situations that may facilitate the transmission of zoonotic diseases in the pet dog owning community were assessed, including playing, greeting, food sources, sleeping areas, walking, disposal of faeces, veterinary preventive treatment and general hygiene. The results may help to inform strategies for the control of zoonotic and other infectious diseases in dogs, and help to quantify the risks associated with dog ownership. However, the assessment of the risks involved, and the nature of any control measures, will depend on the nature of the pathogen and how it is transmitted.

ACKNOWLEDGEMENTS

The authors thank DEFRA for funding the research and the people (and their dogs) who participated in the study.

References

BEAVER, B. V. (1994) Owner complaints about canine behavior. *Journal of the American Veterinary Medical Association* **204**, 1953-1955

BEKOFF, M. & MEANEY, C. A. (1997) Interactions among dogs, people, and the environment in Boulder, Colorado: a case study. *Anthrozoos* **10**, 23-31

BRADSHAW, J. W. S. & LEA, A. M. (1992) Dyadic interactions between domestic dogs. *Anthrozoos* **5**, 245-253

CEFAI, C., ASHURST, S. & OWENS, C. (1994) Human carriage of methicillin-resistant *Staphylococcus aureus* linked with pet dog. *Lancet* **344**, 539-540

CHRISTOPHER, P. J., CLAXTON, P. D., DORMAN, D. C., O'CONNOR, B. F., PROUDFOR, R. W. & SUTTON, R. G. A. (1974) Salmonellosis – increasing health hazard. *Medical Journal of Australia* **1**, 337-341

FISHER, J. (2001) The dog in the human pack. In Think Dog! London, Cassell. pp 25-36

FRIEDMANN, E. (1995) The role of pets in enhancing human well-being: physiological effects. In The Waltham Book of Human-Animal Interaction: Benefits and Responsibilities of Pet Ownership. Ed I. Robinson. Oxford, Elsevier Science. pp 33-53

FUKATA, T., NAITO, F., YOSHIDA, N., YAMAGUCHI, T., MIZUMURA, Y. & HIRAI, K. (2002) Incidence of *Salmonella* infection in healthy dogs in Gifu Prefecture, Japan. *Journal of Veterinary Medical Science* **64**, 1079-1080

GEFFRAY, L. & PARIS, C. (2001) Infectious risks associated with pets. *Medecine et Maladies Infectieuses* **31**, 126S-142S

GLICKMAN, L. T. (1990) Toxocariasis and related syndromes. In Tropical and Geographic Medicine. Eds K. S. Warren, A. A. F. Mahmoud. New York, McGraw-Hill. pp 446-455

GREENE, C. E. & LEVY, J. K. (2006) Immunocompromised people and shared human and animal infections: zoonoses, sapronoses and anthroponoses. In Infectious Diseases of the Dog and Cat. 3rd edn. Ed C. E. Greene. St Louis, Saunders Elsevier. pp 1051-1068

GUY, N. C., LUESCHER, U. A., DOHOO, S. E., SPANGLER, E., MILLER, J. B., DOHOO, I. R. & BATE, L. A. (2001) Risk factors for dog bites to owners in a general veterinary caseload. *Applied Animal Behaviour Science* **74**, 29-42

HACKETT, T. & LAPPIN, M. R. (2003) Prevalence of enteric pathogens in dogs of north-central Colorado. *Journal of the American Animal Hospital Association* **39**, 52-56

HEADEY, B. (2003) Pet ownership: good for health? *Medical Journal of Australia* **179**, 460-461

JACKSON, T. (2005) Is it time to ban dogs as household pets? *British Medical Journal* **331**, 1278

KATCHER, A. H. (1981) Interactions between people and their pets: form and function. In Interrelations Between People and Pets. Ed B. Fogle. Springfield, Charles C. Thomas. pp 41-67

KATCHER, A. H. & FRIEDMANN, E. (1982) Potential health value of pet ownership. *California Veterinarian* **36**, 9-13

LANDSBERG, G., HUNTHAUSEN, W. & ACKERMAN, L. (2003) Prevention: the best medicine. In Handbook of Behaviour Problems of the Dog and Cat. 2nd edn. Edinburgh, W. B. Saunders. pp 27-71

LEJEUNE, J. T. & HANCOCK, D. D. (2001) Public health concerns associated with feeding raw meat diets to dogs. *Journal of the American Veterinary Medical Association* **219**, 1222-1225

LOEFFLER, A., BOAG, A. K., SUNG, J., LINDSAY, J. A., GUARDABASSI, L., DALSGAARD, A., SMITH, H., STEVENS, K. B. & LLOYD, D. H. (2005) Prevalence of methicillin-resistant *Staphylococcus aureus* among staff and pets in a small animal referral hospital in the UK. *Journal of Antimicrobial Chemotherapy* **56**, 692-697

MANIAN, F. A. (2003) Asymptomatic nasal carriage of mupirocin-resistant, methicillin-resistant *Staphylococcus aureus* (MRSA) in a pet dog associated with MRSA infection in household contacts. *Clinical Infectious Diseases* **36**, E26-E28

MCNICHOLAS, J., GILBEY, A., RENNIE, A., AHMEDZAI, S., DONO, J-A. & ORMEROD, E. (2005) Pet ownership and human health: a brief review of evidence and issues. *British Medical Journal* **331**, 1252-1254

MESSENT, P. R. (1983) Social facilitation of contact with other people by pet dogs. In New Perspectives On Our Lives With Companion Animals. Eds A. H. Katcher, A. M. Beck. Philadelphia, University of Pennsylvania Press. pp 37-46

OFFICE FOR NATIONAL STATISTICS (2007) National Statistics. www.statistics.gov.uk/statbase/ssdataset.asp?vlnk=6555&More=Y. Accessed March 31, 2008

PACE, P. J., SILVER, K. J. & WISNIEWSKI, H. J. (1977) Salmonella in commercially produced dried dog food – possible relationship to a human infection caused by *Salmonella enteritidis* serotype Havana. *Journal of Food Protection* **40**, 317-321

PFMA (2004) Pet ownership trends. www.pfma.com/public/petownership.htm. Accessed November 27, 2004

ROBINSON, R. A. & PUGH, R. N. (2002) Dogs, zoonoses and immunosuppression. *Journal of the Royal Society for the Promotion of Health* **122**, 95-98

ROONEY, N. J., BRADSHAW, J. W. S. & ROBINSON, I. H. (2000) A comparison of dog-dog and dog-human play behaviour. *Applied Animal Behaviour Science* **66**, 235-248

SAEED, A. M., HARRIS, N. V. & DIGIACOMO, R. F. (1993) The role of exposure to animals in the etiology of *Campylobacter jejuni/coli* enteritis. *American Journal of Epidemiology* **137**, 108-114

SANDBERG, M., BERGSJO, B., HOFSHAGEN, M., SKJERVE, E. & KRUSE, H. (2002) Risk factors for *Campylobacter* infection in Norwegian cats and dogs. *Preventive Veterinary Medicine* **55**, 241-253

SCOTT, J. P. & FULLER, J. L. (1965) Genetics and Social Behaviour of the Dog.

Chicago, University of Chicago Press. p 63

SIEGAL, S. & CASTELLAN, N., Jr. (1988) Ordered variables and the Gamma Statistic G. In Nonparametric Statistics for the Behavioural Sciences. Ed J. D. Anker. New York, McGraw-Hill. pp 291-298

SMITH, S. L. (1983) Interactions between pet dogs and family members: an ethological study. In New Perspectives On Our Lives With Companion Animals. Eds A. H. Katcher, A. M. Beck. Philadelphia, University of Pennsylvania Press. pp 29-36

TAN, J. S. (1997) Human zoonotic infections transmitted by dogs and cats. *Archives of Internal Medicine* **157**, 1933-1943

TENKATE, T. D. & STAFFORD, R. J. (2001) Risk factors for campylobacter infection in infants and young children: a matched case-control study. *Epidemiology and Infection* **127**, 399-404

WEBER, A., WACHOWITZ, R., WEIGL, U. & SCHAFER-SCHMIDT, R. (1995) Occurrence of ***Salmonella*** in fecal samples of dogs and cats in northern Bavaria from 1975 to 1994. *Berliner und Münchener Tierärztliche Wochenschrift* **108**, 401-404

WEBLEY, P. & SIVITER, C. (2000) Why do some owners allow their dogs to foul the pavement? The social psychology of a minor rule infraction. *Journal of Applied Social Psychology* **30**, 1371-1380

WESTGARTH, C., PINCHBECK, G. L., BRADSHAW, J. W. S., DAWSON, S., GASKELL, R. M. & CHRISTLEY, R. M. (2007) Factors associated with dog ownership and contact with dogs in a UK community. *BMC Veterinary Research* **3**, 5. www.biomedcentral.com/1746-6148/3/5. Accessed March 27, 2008

WIELAND, B., REGULA, G., DANUSER, J., WITTWER, M., BURNENS, A. P., WASSENAAR, T. M. & STARK, K. D. C. (2005) *Campylobacter* spp in dogs and cats in Switzerland: risk factor analysis and molecular characterization with AFLP. *Journal of Veterinary Medicine. B, Infectious Diseases and Veterinary Public Health* **52**, 183-189