# Companion Animals and Child Development: Existing Knowledge and Analysis of the Avon Longitudinal Study of Parents and Children Cohort 

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by Rebecca Purewal.

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#### Abstract

Childhood and adolescence are important developmental phases that influence health and wellbeing across the life span. Social relationships are fundamental to child and adolescent development, yet studies have been largely limited to children's relationships with other humans. Whether pet ownership can exert similar developmental health benefits during childhood is largely unknown. The main aim of this thesis was therefore to investigate the impact of pet ownership on the development in children and young people.

This thesis provides an evidence review of the current literature, and an investigation of the potential associations between pet ownership and emotional; behavioural; cognitive; educational; and language development outcomes, using the analysis of a large cohort dataset, the Avon Longitudinal Study of Parents and Children (ALSPAC).

The review found that pet ownership and the significance of children's bonds with companion animals have been underexplored within child development, and there was a shortage of high quality and longitudinal studies that controlled for confounding. This thesis aimed to address this research gap in the field using ALSPAC data, and in addition, to make an original contribution to knowledge by investigating developmental outcomes that had not yet been previously explored. Data was collected and analysed from approximately 14,000 families via parental and child reports, and clinic assessments. Analyses were adjusted for a wide range of potential confounders, including demographic and socio-economic variables, and to maximise data usage, missing data techniques were applied.

Univariable and multivariable logistic and linear regression analyses were carried out to assess associations between pet ownership (any pet, dog, cat, other) and developmental outcomes. Outcomes investigated were: emotional health (self-esteem, anxiety and depression); behavioural outcomes (emotional difficulties, hyperactivity, conduct difficulties, peer problems and prosocial behaviour); cognitive development (attention, impulsivity and memory); educational attainment (KS1, KS2 and GCSE); and language development (comprehension, vocabulary, social development and non-verbal communication) in childhood. Within emotional health, evidence of an association was found between owning any pet or a cat, and a lower self-esteem (scholastic competence) at age 8 . Further associations were found between any pet or other pet ownership and higher odds of social anxiety at age 7. Within behavioural development, cat ownership was associated with increased odds of hyperactivity at age 3 . Owning any pet, or a cat at age 3 , and owning a dog at both ages 3 and 11 was associated with increased conduct disorder. However owning dogs or other pets was associated with a lower likelihood of experiencing prosocial difficulties at age 3 , and owning other pets was associated with fewer peer problems at age 11. Owning other pets at age 11 was also associated with fewer total behavioural difficulties at age 11. Within cognitive development, dog ownership was associated with poorer attentional switching at age 11. Pet ownership was consistently associated with lower educational attainment in a number of different subjects across ages, despite adjustment for logical confounders. Lastly, pet ownership was associated with a higher score in language comprehension at age 5, and a higher non-verbal communication score at age 2 .


This thesis finds no clear patterns across developmental outcomes, pet types or child age in the ALSPAC dataset. Pet ownership does not appear to be associated with improved emotional health, cognitive or educational development of children. Owning pets may however, have a positive impact on social development as seen through the positive associations in language development and prosocial behaviour. This thesis demonstrates the importance of using large, well-designed longitudinal studies that control for key confounders. Future research needs to incorporate ageappropriate pet attachment or pet bonding measures into future cohort studies in order to determine whether the relationships we have with our pets are of more importance than pet ownership in conferring developmental benefits.

## Publications

Parts of this thesis have been published and presented elsewhere:

## PEER-REVIEWED PUBLICATIONS

Purewal R, Christley R, Kordas K, Joinson C, Meints K, Gee N, Westgarth C. (2017). Companion Animals and Child/Adolescent Development: A Systematic Review of the Evidence. International Journal of Environmental Research and Public Health. 14(3). doi:10.3390/ijerph14030234.

Purewal R, Christley R, Kordas K, Joinson C, Meints K, Gee N, Westgarth C. (2019). Socio-demographic factors associated with Pet Ownership amongst Adolescents from a UK Birth Cohort. BMC Veterinary Research, 15, 334. doi:10.1186/s12917-019-2063-x

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Published manuscripts are located at the end of the thesis.

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## List of Abbreviations

| AAI | Animal Assisted Intervention |
| :---: | :---: |
| AAT | Animal Assisted Therapy |
| ACC | Anterior Cingulate Cortex |
| ACEs | Adverse Childhood Experiences |
| ALEC | ALSPAC Law and Ethics Committee |
| ALSPAC | Avon Longitudinal Study of Parents and Children |
| ADHD | Attention deficit hyperactivity disorder |
| ASD | Autism Spectrum Disorder |
| CCI | Crown-Crisp Experiential Index |
| CD | Conduct disorder |
| CES-D | Centre for Epidemiological Studies Depression Scale |
| CiF | Children in Focus |
| CSE | Certificate of Secondary Education |
| CYP | Children and Young People |
| DAWBA | Development and Wellbeing Assessment |
| DSM | Diagnostic and Statistical Manual of Mental Disorders |
| EF | Executive Function |
| EPDS | Edinburgh Postnatal Depression Scale |
| GCSE | General Certificate of Secondary Education |
| HAI | Human-Animal Interaction |
| HPA | Hypothalamic-pituitary-adrenal axis |
| HSPP | Harter Self-Perception Profile |
| ICD | International Classification of Diseases |
| KS1 | Key Stage 1 |
| KS2 | Key Stage 2 |
| MAR | Missing at random |
| MCAR | Missing completely at random |


| MNAR | Missing not at random |
| :--- | :--- |
| MCDI | MacArthur Communicative Development |
|  | Inventories |
| MCMC | Markov chain Monte Carlo |
| MFQ | Moods and Feelings Questionnaire |
| MICE | Multiple Imputation by Chained Equations |
| MNAR | Missing not at random |
| MKO | More Knowledgeable Other |
| OCEBM | Oxford Centre of Evidence Based Medicine |
| ODD | Oppositional Defiant disorder |
| PA | Pet Attachment |
| PO | Pet Ownership |
| PRISMA | Preferred Reporting Items for Systematic |
| RDLS | Reviews and Meta-Analyses |
| RDST | Reynell Development Language Scale |
| RRS | Relational Developmental Systems Theory |
| SAPS | Revised Rutter Scale |
| SAT | Short Attachment to Pets Scale |
| SDQ | Standard Assessment Test |
| SES | Strengths and Difficulties Questionnaire |
| SNS | Socio-economic status |
| SPPC | Special Needs Status |
| TEACh | Self Perception Profile for Children |
| WHO | Tests of Everyday Attention for Children |
| ZPD | Worlth Organization |

I have always had a fascination in, and an appreciation for animals and nature. I was not born into a pet-loving family. My love of animals almost seemed to be innate. I begged my parents to be allowed to own a pet throughout my childhood. When I was 10 years old, my parents finally gave in, and I took the opportunity to own as many pet types as possible- fish, mice, hamsters, gerbils, guinea pigs, and rabbits until I was finally allowed to own a dog. I had never put much thought into how animals can affect us as humans. At times, my childhood was difficult. As a result, I sometimes felt and believed I was helpless and powerless to enforce change. Having pets of my own to nurture, not only gave me a distraction, but also allowed me to collect evidence against those beliefs; if I could provide a happy and healthy life for a pet that was dependent on me, perhaps I was not so helpless or powerless after all.

This schema, of being able to challenge my core belief (being powerlessness to make change) by helping others, was likely what attracted me to work in a caring profession. During my time as an Assistant Psychologist in an Early Intervention in Psychosis, and Child and Adolescent Mental Health Service, I saw further evidence of the positive effects pets can have on client's lives. In therapy sessions, clients would commonly talk about how important their pets were to them, as a protective factor of mental health. Children who were usually withdrawn and difficult to engage would thrive when the 'Pets as Therapy' dog came into the hospital. Despite recognising the important role pets were playing in client's lives, I, as other clinicians, rarely addressed it. As part of my training, I am required to fulfill core competencies within clinical psychology, one that states clinical practice should be grounded on scientific evidence based research. As a result, I am skeptical of claims with no evidence base, and there is very little known about the role pets play in human psychological health, particularly
in children. However, I have always had a curiosity about the impact of pet ownership, and what effects we could be missing.

For the vast majority of the population, pets become valuable members of the family. If pets do have influences on how children develop, their role has not just been underestimated, but overlooked. This thesis sets out to investigate whether pets do indeed have any impact on the development of children and adolescents.

Chapter I

Introduction

This chapter aims to demonstrate the importance of investigating in the impact of pets on child development. Firstly, it describes the current climate of developmental issues in childhood in the UK including the rise of mental health difficulties, the increase in child poverty and the lack of widely available and effective psychological intervention. Explanation is provided on how pet ownership may address these current issues by exerting both positive developmental benefits to the individual child and changes in the home environment, which may ultimately impact societal or population health. A brief overview is then provided on what studies have been carried out already in the field. Lastly, aims and hypotheses for the present study are stated.

### 1.1 Background

Childhood and adolescence are crucial life phases for contribution to the quality of health, emotional well-being, learning and behaviour across the life span (WHO, 2016). Emotional disorders, such as such as separation and social anxiety disorder, are relatively common in Children and Young People (CYP); the estimated prevalence in 5-16 years olds in the UK is 4\% (Public Health England, 2015). Common emotional disorders such as anxiety and depression often start in childhood and persist into young adulthood due to long treatment delays (Costello, Egger, \& Angold, 2005; Kessler et al., 2012; Lahey, 2015). The estimated prevalence of behavioural disorders in CYP aged 5-16 years is slightly higher at 6\% (Public Health England, 2015). Disruptive behavioural problems such as temper tantrums, attention deficit hyperactivity disorder (ADHD), oppositional defiant (ODD) or conduct disorder (CD) are among the most common disorders in preschool and school age children (Ogundele, 2018). However, behavioural and emotional disorders usually go hand-inhand. Around $50 \%$ of all CYP with an emotional health disorder have a conduct disorder (CD) (Dretzke et al., 2005). Building self-esteem, self-efficacy and supporting the development of social and emotional skills amongst CYP may be an effective early intervention for emotional and behavioural problems as issued by The National Institute for Health and Care Excellence (NICE, 2013).

Early enhancement of cognitive function (Executive Function (EF), general intelligence, and language) sets a child on a trajectory for success in later life. For example, EFs (cognitive processes such as attention and memory) are predictive of achievement throughout life, often more so than IQ or socioeconomic status (Moffitt, 2012; Moffitt et al., 2011). Evidence suggests that early honing of EFs can reduce the later incidence of school failure, substance abuse and addictions, aggression, crime,
antisocial behaviour, and early death (Ling, Kelly, \& Diamond, 2016). Novel, costeffective interventions that are able to hone EFs are needed, particularly in children who display symptoms of depression, conduct disorder and ADHD, which are currently among the most pressing public health issues. In addition, other relevant policy issues include the need for an informal 'at home' intervention to attempt to reduce the rate and length of hospital stays and to provide for at-risk youths to lower the incidence of problem behaviours (Esposito, McCune, Griffin, \& Maholmes, 2011). The current increase in poverty within the UK is also an important factor affecting child cognitive and educational development (Dickerson \& Popli, 2018; TaylorRobinson, Lai, Whitehead, \& Barr, 2019) and can affect school readiness (Cates, Weisleder, \& Mendelsohn, 2016).

In order to thrive, children also need the opportunity to build strong relationships to increase their confidence, inspire curiosity, provide social support, and increase hope within a happy and interactive home environment. Relationships with others are fundamental contributors to child and adolescent development according to relationship psychology (Fogel, 1993) and attachment theory (Bowlby, 1969). Yet, studies of child development have largely been limited to children's relationships and interactions with other humans. However, animal ownership is common. Recent figures indicate that $68 \%$ of U.S. households (American Pet Products Association, 2014), $62 \%$ of Australian households (Animal Medicines Australia, 2016) and $46 \%$ of British households (Pet Food Manufacturers Association, 2014) include at least one companion animal. Moreover, epidemiological studies suggest that pets are more likely to be found in households with children than in any other household type (Melson, 2003; Westgarth et al., 2010; Westgarth et al., 2007; Westgarth et al., 2010b).

Pets are considered by most to be members of the family (Cain, 2016). Children have also been shown to have strong bonds with their pets (Hawkins \& Williams, 2017; Melson, Peet, \& Sparks, 1991). Although pet ownership and children's bonds with companion animals may have the potential to positively influence child and adolescent development, these relationships have received little attention and a need for research in this area has been recognized (Endenburg \& van Lith, 2011; Melson, 2003).

Previously, companion animals were seen as inferior replacements for human social interactions. However, partly in response to the scepticism of the medical establishment in the 80s, therapeutic benefits of animal companionship started to be scientifically explored (Serpell, 2000). Research into the health benefits of owning companion animals is currently on the rise; such research is timely. As technology advances, we are moving into an increasingly online and virtual world, where contact between people is declining. We are living through a crisis of touch and tactile stimulation, which is important for healthy mental wellbeing and development (Walker \& McGlone, 2013). Pets are an obvious substitute for providing tactile stimulation. In addition, public health issues such as anxiety and depression (NHS Digital, 2018), and obesity and diabetes (Candler et al., 2018) in childhood are on the rise in the UK. Pet ownership may have the potential to address these current mental and physical health crises by providing social support (McNicholas \& Collis, 2000), reducing stress (Polheber \& Matchock, 2014) and encouraging physical activity (Westgarth et al., 2019; Westgarth, Knuiman, \& Christian, 2016).

Almost all young children have a particularly profound, nearly instinctive interest in animals (Julius, 2013) explained by the Biophilia hypothesis (Wilson, 1984) that assumes that humans' social behavioral systems have evolved to take an interest
in nature and animals. It is clear to see how pets may affect the social developmental nature of youths in childhood and adolescence by:

- Honing a capacity to enter into and sustain mutually satisfying relationships
- Providing an ability to play and learn so that attainments are appropriate for age and intellectual level
- Helping to develop an understanding of how other's perceptions can differ from one's own through parental guidance (Theory of Mind), and to develop a moral sense of right and wrong.

In view of the increasing pressures on mental and behavioural health spending, and the difficulty in access to specialist interventions, there is growing evidence that prevention and early intervention may be a more cost-effective and widespread way to support a healthier developmental path (British Medical Association, 2013) and improve societal health (Blackburn with Darwen Partnership, 2017). The majority of preceding research has been focused on therapeutic intervention where justification for the inclusion of animals in these interactions is often based on anecdotal evidence and short-term observation. Animals are commonly used in psychotherapy (Prothmann, Bienert, \& Ettrich, 2006) and animal-assisted therapy (Goddard \& Gilmer, 2015) to positively change children's states of mind, increase desire for social contact, and facilitate children in becoming psychologically well balanced (Prothmann et al., 2006).

Experimental study with animals has shown children benefit from the presence of dogs for cognitive tasks such as object recognition (Gee, De, Riley, Belcher, \& Grabski, 2012), object categorization (Gee, Church, \& Altobelli, 2010; Gee, Gould, Swanson, \& Wagner, 2012) and memory (Gee, Crist, \& Carr, 2010; Gee, Friedmann,

Coglitore, Fisk, \& Stendahl, 2015). They are also are commonly used in educational settings such as classrooms (Brelsford, Meints, Gee, \& Pfeffer, 2017; O'Haire, Slaughter, McKenzie, \& McCune, 2013) to support concentration, attention, motivation and relaxation (Beetz, Uvnäs-Moberg, Julius, \& Kotrschal, 2012). However, the extent to which these findings can be generalized to pet ownership and the presence of pets in the home is unclear. If pet ownership is able to promote healthy psychological development in the community and prevent the onset of childhood emotional and behavioural and cognitive health difficulties, this may contribute to an effective system transformation in health services by reducing the level of need in society (Faulconbridge et al., 2016). In order to develop an evidence base to inform and advise whether pets should be introduced to families to positively affect healthy child development, more research is needed.

This thesis is primarily concerned with psychological development between the ages of 2 and 16 years; a period during which the most profound changes occur in emotional, cognitive, language and social development. The thesis takes a developmental approach, and is pan-theoretical insofar as it rests on an acceptance that ideas from different developmental theories can be applied to child-pet interaction depending on developmental outcome.

Aims

The overarching aim of this PhD research project is to investigate the associations between pet ownership and child developmental outcomes in the Avon Longitudinal Study of Parents and Children (ALSPAC) - a well-characterised, large contemporary UK birth cohort of children.

Objectives:

1. To determine the evidence base for the impact of pet ownership and pet attachment on childhood and adolescent development
2. To understand pet ownership in adolescence (identify and describe the potential confounding factors associated with ownership of each pet type in adolescence), and to compare findings in adolescence to childhood from the same cohort
3. To investigate the impact of pet ownership on emotional health (self-esteem, anxiety and depression) and behavioural outcomes (emotional difficulties, hyperactivity, conduct difficulties, peer problems and prosocial behaviour) in childhood and adolescence using ALSPAC
4. To investigate the impact of pet ownership on cognition (attention, impulsivity and memory), educational attainment (KS1, KS2 and GCSE) and language development in childhood and adolescence using ALSPAC
1.2 Synopsis and structure of the thesis

Chapter 1 introduces the project, and provides a background for the justification of researching the impact of pets on child development, in terms of societal benefit.

Chapter 2 explores the theoretical plausibility for the impact pets may have on child development. Several theories are explored in order to take a pan-theoretical approach. These include neuroscience and biological responses, social buffer effects, selfregulation, attachment theory, and developmental psychology theories.

Chapter 3 explores the existing evidence base for the impact of pets on child development, along with identification of research gaps. The inconsistent evidence regarding the health impacts of pet ownership in childhood and adolescence is a common problem in HAI studies and may be due to a wide diversity of designs, small effect sizes, and small and homogeneous self-selected samples, as well as incomplete adjustment for relevant confounders (Barba, 2015).

Chapter 4 introduces the ALSPAC dataset and overarching methodology for the project. Detail on participants, ethical procedures, and an overview on ALSPAC including strengths and limitations of the dataset are presented.

The pet ownership data in ALSPAC are described, including what, when and how data were collected. Previous research has identified the need to control for sociodemographic differences in ownership of different pets types in children (Westgarth et al., 2010). This chapter outlines the aims to extend this research to pet ownership in adolescence in the present study.

An overview of the chosen developmental outcomes in ALSPAC are also given, including an introduction to the developmental outcomes, and information on when and how they have been measured and collected in ALSPAC. Lastly, research hypotheses are given for each developmental outcome.

Lastly, data analysis procedures are explained including statistical analyses for each developmental outcome, the selection of confounding variables according to developmental outcome, and missing data procedures.

Chapter 5 presents the predictors of pet ownership results; pet ownership trends in ALSPAC; and sociodemographic factors in adolescent pet ownership

Chapter 6 presents the emotional health (self-esteem, anxiety and depression), and behavioural development results (emotional difficulties, hyperactivity, conduct disorder, prosocial difficulties). It finds little evidence of an association between pet ownership and emotional health, but some evidence between pet ownership and behavioural development outcomes.

Chapter 7 presents the cognitive (attention, impulsivity and memory), educational attainment (KS1, KS2, GCSE) and language development results (comprehension, communication, vocabulary, non-verbal communication and social development). It finds some evidence of an association between pet ownership and educational and language outcomes.

Chapter 9 consists of a summary of the main findings, and a discussion of the significance and implications of the key findings of this thesis along with recommendations and areas for future research. Strengths and limitations of the study are also discussed.

Chapter II

Theory

As the field is relatively new, few publications exist describing the theory behind how child-pet relationships can affect child health outcomes. This chapter aims to explore the theoretical plausibility for the impact pets may have on child development. Several theories are explored in order to take a pan-theoretical approach. These include neuroscience and biological responses, social buffer effects, self-regulation, attachment theory, and developmental psychology theories. Novel to this study, more recent developmental theory for language acquisition is applied for the impact pets may have on cognitive and language development.

This thesis focuses on and defines Child Development as the emotional, behavioural, cognitive, educational and language changes that occur between infancy to adolescence.

The terms Companion Animals and Pets are used interchangeably throughout the thesis, and are defined as a domesticated animal kept in the household for company and enjoyment of the owner/s.

Several theories exist to explain how companion animals may affect child development. Such theories include biological responses, social support theory, selfregulation, attachment and developmental theory, which are briefly explained below. It is likely that these mechanisms interact within an integrative biopsychosocial model, in which social, psychological, and biological pathways influence wellbeing and development.

### 2.1 Neuroscience and biological/hormonal response

Physiological mechanisms may in part reduce psychological stress for humans who are in contact with animals. Interaction with pets can mediate human physiological responses to stressors and anxiety, and as research suggests, may improve mental, social, and physical health (Beetz, Uvnäs-Moberg, et al., 2012; Polheber \& Matchock, 2014). Pet ownership may indirectly improve emotional states, emotional regulation and cognition through improving cognitive executive functions (EFs) (Boyer, 2014; Ling et al., 2016; Sugawara et al., 2012). EFs are mental processes that underlie planning, attention, memory and self-control, subserved by the prefrontal cortex of the brain (Boyer, 2014; Ling et al., 2016). Maturational changes in EFs develop over the first two decades of life, meaning infancy and childhood may be the optimal time for pet ownership.

Interaction with pets can also affect the endocrine system. Beetz, UvnäsMoberg, et al. (2012) reviewed the effects of human-animal interaction (HAI) on oxytocin, cortisol, epinephrine, and norepinephrine on the attenuation of stress responses. The role of oxytocin in particular has received much attention in explaining positive effects of HAI, and has been found to increase in the presence of a pet (Beetz, Uvnäs-Moberg, et al., 2012). Oxytocin release can stimulate social interaction, increase social skills, increase positive self-perception, and decrease depressive symptoms (Beetz, Uvnäs-Moberg, et al., 2012; Cardoso, Ellenbogen, \& Linnen, 2012; Heinrichs, Baumgartner, Kirschbaum, \& Ehlert, 2003). Oxytocin also has an anxiolytic effect for social anxiety (Guastella, Howard, Dadds, Mitchell, \& Carson, 2009) and social fear (Kirsch et al., 2005). The role of oxytocin may be important for other theories that explain the emotional health benefits of pet ownership, such as attachment theory (Bowlby, 1969), biophilia (Wilson, 1984), and social support theories (Wills, 1991). In terms of other neurotransmitters, tactile responses and reciprocal love from pets can increase dopamine and serotonin production (Beetz, Uvnäs-Moberg, et al., 2012), and reduce the production of cortisol by the hypothalamic-pituitary-adrenal axis (HPA) (Julius, 2013; Polheber \& Matchock, 2014). Cognitive developmental processes such as enhanced attention and concentration have been linked to dopaminergic systems (Genro, Kieling, Rohde, \& Hutz, 2010), and reduced cortisol (Finegood, Wyman, O'Connor, Blair, \& Family Life Project, 2017).

### 2.2 Emotional buffer and social support

Pet ownership is hypothesised to provide emotional protection from the stresses and pressures of life (the 'buffer' effect) (McNicholas et al., 2005; Melson \& Fine, 2010). Self-psychology (self-esteem, self-cohesion and self-acceptance) is a particularly important aspect of youth development. Particularly in early and preadolescence, developmental changes in self-esteem have a significant impact and fluctuate prominently, with large decreases in self-esteem during transition to adolescence (Simmons, Rosenberg, \& Rosenberg, 1973). Low self-esteem has been shown to give rise to poorer mental health (Henriksen, Ranøyen, Indredavik, \& Stenseng, 2017). The recent increases in loneliness in this age group (Office for National Statistics, 2018) can also lead to increasing anxiety and depression rates.

Companion animals can act as social facilitators or catalysts for interpersonal human social interactions (social-catalyst effect) (McNicholas \& Collis, 2000), which in turn may reduce loneliness, social anxiety and depression, and increase self-esteem (Purewal et al., 2017). Additional benefits include increased social networks and social capital (Wood et al., 2017), which are important in the emotional development of children (Blackburn with Darwen Partnership, 2017; Endenburg \& van Lith, 2011) and which enhance self-esteem (Cochran \& Brassard, 1979) and protect against psycho-social stress (Cohen \& Wills, 1985).

Alternatively, pets themselves can be viewed as supportive companions (Enders-Slegers, 2000; McNicholas \& Collis, 2001; Pachana, Massavelli, \& RobledaGomez, 2011). It is likely that pets create a sense of connectedness and belonging, similar to peers in human relationships (Serpell, 1986). Supporting this, a study found that social needs fulfilment by pets was positively associated with subjective wellbeing in their human companions, and counteracted the negative effects of social
rejection (McConnell, Brown, Shoda, Stayton, \& Martin, 2011). Lazarus and Folkman proposed a theory of Stress and Coping (Lazarus \& Folkman, 1984), where attachment to pets can act as a both a physiological and psychological coping mechanism. It has been theorised that children perceive pets as significant social support, especially when feeling distressed (Brown, 2007; Melson, 2003). Children may also use pets as a surrogate to provide unconditional positive regard, approval, and acceptance without judgement they lack from caregivers or peers (Melson, Schwartz, \& Beck, 1997; Triebenbacher, 1998; Veevers, 1985). Research has demonstrated that children derived more satisfaction and engaged in less conflict with their pets than with their siblings (Cassels, White, Gee, \& Hughes, 2017). Gaining this type of emotional support is essential for the healthy psychological development in childhood and adolescence, especially during periods of growth, developmental changes, and challenging social situations.

Research has stressed the importance of youth's relationships with their parents and peers during the transition from adolescence to adulthood (Sillars, Koerner, \& Fitzpatrick, 2005), when poor communication and conflict are associated with poorer psychological well-being and quality of life (Zhiwen, Xiaoming, \& Stanton, 2011). However, attachment to pets moderated this effect of poor communication with parents and peers, and also their quality of life (Marsa-Sambola et al., 2016). Furthermore, children have been found to rely on pets during high stress occurrences such as parental disputes (Strand, 2004); and it is theorised that these children who use pet interaction as a stress-buffer may exhibit fewer behavioural difficulties due to the ability to regulate emotional reactions to environmental stressors leading to the facilitation of healthy coping skills (Strand, 2004). Pets are assumed to have an even stronger impact
in adolescents with a higher risk of social isolation (Black, 2012; Marsa-Sambola et al., 2016).

### 2.3 Self-regulation

Owning pets can provide the opportunity for children to practice selfregulation and emotional regulation (the ability to manage feelings and behaviours) during interaction with pets guided by adults (Boyer, 2014). People capable of self and emotional regulation, and who have well developed EFs, feel more equipped in personal control over external events (Boyer, 2014). In addition, they have a better ability to initiate, modulate, and cease both emotional responses and emotion-based behavioural responses across varied experiences (Boyer, 2014). Children prefer to project their impulsive personal feelings initially onto 'non-judgemental' companion animals as a means of regulating their anger, sadness and happiness (Walsh, 2009). It has been hypothesised that companion animals can assist children in the acquisition of self-regulation and emotion regulation through mentoring, teaching and learning, socializing, and injecting recreational calm (Boyer, 2014), as well as play (Boyer, 2014; Lillard et al., 2013). Research has found that having a successful, adaptive social relationship with an animal (in comparison to another human being) may be related to a more differentiated set of self-regulatory skills (selection, optimization, and combined compensation/loss-based selection) (Mueller, 2014). In the same study, youths without any HAI (no social relationship with an animal) showed a more general self-regulation structure, with little differentiation between these three skills. Another potential way pets could influence the development of self-regulation is through stress regulation. As EFs are negatively impacted by chronic stress (Diamond, 2013) but
improved by social support (Diamond, 2015), pet interaction may indirectly improve self-regulation.

However, it is important to determine whether pet interaction promotes the development of these skills, or whether children who have highly developed selfregulatory abilities are more likely to be in contact with companion animals (Mueller, 2014). If pet ownership can enhance self-regulation, it may assist in the prevention of public health issues resulting from Early Adverse Childhood Experiences (ACEs) such as mental health difficulties, risky and impulsive behaviour, chronic health conditions, and low life potential (Centers for Disease Control and Prevention, 2016a).

Self-regulation skills may also emphasize key social and emotional skills that impact school readiness and later school success (Gee, Griffin, \& McCardle, 2017). Young children who are more adept at self-regulation are more likely to acquire early academic skills (Graziano, Reavis, Keane, \& Calkins, 2007) and in contrast, lower levels of self-regulation has been shown to place students at educational risk (Blair \& Diamond, 2008).

### 2.4 Attachment theory

Attachment is an innate 'deep and enduring emotional bond that connects one person to another across time and space' (Ainsworth, 1973; Bowlby, 1969). According to attachment theorists, when attachment behaviours are consistently met by the primary caregiver (e.g. by responding sensitively and appropriately to the child's needs), children form secure internal working models. That is, a cognitive framework consisting of mental representations for understanding the world, self and others that is foundational for their ability to make affectionate bonds with others and to create
and maintain close relationships (Bowlby, 1969). A secure attachment to human caregivers has a protective effect against psychopathology (McGoron et al., 2012) and is related to empathy and prosocial behaviour development (Thompson \& Gullone, 2008). On the contrary, insecure attachments to human caregivers can have long-term negative consequences for a child's mental health, well-being, and behaviour and is a risk factor for anxiety disorders (Schimmenti \& Bifulco, 2015) and delinquency (Hoeve et al., 2012). Although psychological theories of attachment concentrate on attachment between humans, research has demonstrated that children display attachment behaviours towards their pets (Melson \& Fogel, 1989). In addition, pets may have the potential to function as a substitute for insecure attachment to parents (Purewal et al., 2017).

A study conducted with a UK sample of youths found that the majority of children who owned pets scored highly on pet attachment (Hawkins \& Williams, 2017). However, attachment scores differed depending on pet ownership, pet type, and gender of the child (Hawkins \& Williams, 2017). In sum, attachment to pets may have an important role in children's social, emotional, and cognitive development, mental health, well-being, and quality of life (Hawkins \& Williams, 2017).

As of yet, there is no unified developmental theory that could explain the role pets may play in child development. Described here separately are Piaget's theory of cognitive development, Vygotsky's social development theory and the AnimateInanimate Distinction theory. Furthermore, more recent theories in developmental psychology are applied; usage-based language acquisition and the emergentist coalition model.

### 2.5.1 Piaget's theory of cognitive development

Piaget's theory of cognitive development assumed that children undergo progressive reorganization of mental processes as a result of both biological maturation and environmental experience (Inhelder \& Piaget, 1969). He stated that children construct an understanding of the world around them, and it is their experience of interacting with their environment, which causes discrepancies between what they already know and what they discover in their environment.

Piaget (Inhelder \& Piaget, 1969) identified four major periods of cognitive development which reflect the increasing sophistication of children's thought: the sensorimotor stage (birth to age 2), the preoperational stage (from age 2 to age 7 ), the stage of concrete operations (from age 7 to age 11), and the formal operation stage (age 11+ to adolescence and adulthood).

The sensorimotor stage's main attainment is Object Permanence (knowing that an object still exists even when it is not in view). During the preoperational stage, children develop the ability to challenge the belief that only moving things are alive. The concrete operations stage is considered a major milestone for cognitive development
as the child begins to take into account another's perspective, think logically and is capable of internal cognition. Lastly, the formal operations stage is where the child begins to think about abstract concepts, and logically test hypotheses.

Younger children (i.e., children in the preoperational stage) are exercising the development of many concepts, including social relationships by interacting with their environment and beings around them. Therefore, interacting with pets could be hypothesized to promote young children's cognitive development in particular. Pet interaction during this developmental stage may enhance perspective taking and prosocial behaviour. If pets can aid in the diminishment of egocentrism, and scaffold theory of mind processes, it is plausible that language development may also be indirectly improved.

Features of Piaget's theory can also be applied to education; if children's learning is optimized when it occurs within meaningful relationships (Vygotsky, 1978), and they retain more information by actively exploring, and being emotionally invested in the subject, it is plausible that pets may enhance learning (Melson, 2003).

Although Piaget was a pioneer within cognitive development, and has opened up the field to recognise children as active investigators, there is much critique in his methodology and findings. Not only were small sample sizes used and sociocultural differences not taken into account (Matusov \& Hayes, 2000), a major criticism stems from the idea of a 'stage' theory; individual differences exist in children which means children can display a mixture of abilities within different 'stages' (Gray, 1994; Weiten, 1992). Piaget also underestimated the development of young children in being overly egocentric (Bower, 1982).

### 2.5.2 Vygotsky's Social Development theory

Vygotsky's theory proposes a different mechanism of development, which emphasises the fundamental role of social interaction and social-cultural factors in the development of cognition (Vygotsky, 1978). He argues that the construction of knowledge and cognition interacts with the ability to communicate with others, rather than our independent exploration and interaction with the material world, as suggested by Piaget. Vygotskian theory suggests cognitive development stems from social interaction with a skilful tutor via co-construction (scaffolding) of knowledge; therefore adults and peers are an important source of learning. The two main principles of Vygotsky's theory are 1) the More Knowledgeable Other (MKO) and 2) the Zone of Proximal Development (ZPD). The MKO is an individual who holds more knowledge or understanding than the child. The ZPD is a concept that relates to the difference in what the child is able to achieve independently verses what a child can achieve from guidance from a skilful other or a MKO. Higher mental functions can be developed in learning from knowledgeable others. Parental guidance about pet care and pet interaction may scaffold children's learning. Whether pets can act as a form of MKO themselves to scaffold children's learning is unknown.

Within Vygotskian theory, more emphasis is placed on the role of language development as a driver for cognitive development. He proposed three language forms 1) Social Speech: from 2 years + children use external communication to interact with others, 2) Private Speech: thought and language systems are said to merge at around 3 years old to produce an internalization of language or 'verbal thought', known as inner speech and 3) Silent Inner Speech: from age 7 years children use silent inner speech to self-regulate behaviour (Vygotsky, 1978).

For cognitive development, private speech is an important accelerator, which enables social competency, and facilitates processes such as overcoming task obstacles and enhances imagination. Vygotsky stated that children raised in cognitively and linguistically stimulating home environments start using private speech earlier, and children raised in home environments of low social and verbal interaction experience delays in private speech (Vygotsky, 1987). Pets in the home not only act as a subject of conversation, but may respond to verbal interaction (Endenburg \& van Lith, 2011; Geerdts, Van de Walle, \& LoBue, 2015). It is unknown, but plausible that pet-owing infants and children may benefit from a more linguistically stimulating environment, leading to enhanced private speech. This enhanced private speech could lead to improvements in cognitive development. It is also plausible that when children talk to their pets, they externalise their private speech resulting in enhanced cognitive and verbal abilities.

### 2.5.3 Animate-Inanimate Distinction in infancy

The onset of the Animate-Inanimate distinction, where children recognise living beings from non-living objects begins early in life (Mandler, 2000; Rakison \& Poulin-Dubois, 2001), is uniform across cultures (Atran, 1999) and acts as a building block for more complex abilities, including word learning (Childers \& Echols, 2004). Whether pet ownership enhances cognitive development within animate-inanimate distinction is unknown. It is plausible to suggest children who own pets may reliably distinguish animates from inanimates at an earlier age. Pets give cues that may help children decide whether something is animate or inanimate. These cues can be split into two classes: featural (whether or not it has a face; the texture of its contour (metal
vs. fur); wheels versus legs (Rakison \& Butterworth, 1998)) and dynamic (aspects of the object's motion).

The animate-inanimate distinction can aid the development of other aspects of cognitive and linguistic development. This may include: categorization (Barrett, Abdi, Murphy, \& Gallagher, 1993), meta -linguistic judgments (Schwartz, 1980), syntax (Croft, 2002), and theory of mind (Lillard, Zeljo, Curenton, \& Kaugars, 2000) and physical reasoning (Heyman, Phillips, \& Gelman, 2000). Pet owning children may also grasp concepts such as life and death more rapidly, and have a better understanding of biology specific processes specific to living beings such as metamorphosis, healing, reproduction, illness, and contagion (Opfer \& Gelman, 2011).

### 2.5.4 Cognitive Linguistic theory

Usage-based and emergentist approaches are more recent models in language acquisition, which state that language can be learned from language use itself, by means of social skills like joint attention, and powerful generalization mechanisms (Behrens, 2009). They are relevant, but have not yet been applied to pet ownership and cognitive/language development.

### 2.5.5 Usage-Based Language Acquisition Theory

Usage-based language acquisition theory is a relatively recent cognitive development theory developed by Tomasello (Cameron-Faulkner, Lieven, \& Tomasello, 2003) that assumes word learning is similar to other social-learning processes. The theory assumes that linguistic skills and language development arise as a by-product from the accumulated experience of social interaction or 'usage events' through entrenchment (a repeated encounter of a unit leaves memory traces that stabilize the more often this unit recurs (Behrens, 2009)). It is plausible to suggest that entrenchment may occur whilst watching others teach pets verbal commands, or teaching the pet themselves. Children also learn the meaning of words in cultural routines such as feeding and changing, when the child and parent shares joint attention to a situation. This enables the child to understand the communicative intent of the parent (Cameron-Faulkner et al., 2003; Liszkowski, Carpenter, Henning, Striano, \& Tomasello, 2004). Sensitivity to social cues are also deemed of importance in this process e.g. eye gaze, pointing, and speaker intention. Attention to social cues like eye gaze direction has been shown to predict language outcome (Brooks \& Meltzoff,
2008). It is clear to see how these social cues are used in pet interaction, where the reliance of verbal commands alone is rarely sufficient.

### 2.5.6 Emergentist Coalition Model

The Emergentist Coalition Model (EMC) is a hybrid theory that states language acquisition arises from multiple factors such as cognitive constraints, social-pragmatic factors, and global attentional mechanisms (Hirsh-Pasek, Golinkoff, Hennon, \& Maguire, 2004; Hollich et al., 2000). The child is assumed to learn new words by both innate biases and environmental cues, which they weight differentially over time. The EMC makes three assumptions (Hollich et al., 2000):

1. In order to learn words, children are sensitive to multiple cues, attentional, social, and linguistic.
2. Children differentially weigh certain cues over others in the course of word learning (word learning starts out as an associative process and gradually becomes a process reliant on social and linguistic information).
3. Principles of word learning are emergent as each principle changes from an immature to a mature state.

Here, it can be perceived that pets gain a perhaps innate attentional interest from infants and young children through being interactive. Through joint attention from parents, children are then able to learn through social and linguistic cues when the parent and child talk about or talk to the pet. Over time and with practice, and due to repeated word use, children become well practised and are then able to apply and test out abstract knowledge to novel situations.

The next step in the project is to determine what research has been led in the area already in regards to the impact of pet ownership on child development, and identify research gaps for the thesis.

## Review of Related Literature

A version of this chapter has been published in the International Journal of Environmental Research and Public Health (Purewal et al., 2017).

Purewal, R., Christley, R., Kordas, K., Joinson, C., Meints, K., Gee, N., \& Westgarth, C. (2017). Companion Animals and Child/Adolescent Development: A Systematic Review of the Evidence. International Journal of Environmental Research and Public Health, 14(3) doi: 10.3390/ijerph14030234

This is the first literature review looking at the impact of pets on child development. This chapter aims to explore the existing evidence base for the impact of pets on child development, and to provide the reader with some familiarity of previous research in the field. It also aims to find research gaps for the current project in terms of developmental outcome and research design, in order to gain insight into where and how the field needs to be taken forward.

### 3.1 Introduction

Companion animals (including horses, dogs, cats, rabbits and other rodents) have the potential to promote healthy youth development in many ways, as shown by research in Human-Animal Interactions (HAI). HAI has been defined as the mutual and dynamic relationships between people and animals and the ways in which these interactions may affect physical and psychological health and well-being of both people and their pets (Esposito et al., 2011). Interactions with animals may affect several aspects of human development: emotional, behavioural, cognitive, educational and social. This chapter uses the term "youth" development to refer to all age ranges within Infancy (0-2 years), Early childhood (2-5 years), Later childhood (6-12 years) and Adolescence (13-18 years).

Companion animals and emotional health
There is growing evidence that children turn to their pets for comfort, reassurance and emotional support when feeling anger, sadness, or happiness (Bryant, 1990; Covert, Whiren, Keith, \& Nelson, 1985; McNicholas \& Collis, 2001; Melson \& Schwarz, 1994). Thus, it is plausible that companion animals may have the potential to encourage better emotional health and reduce anxiety and depression. Physiological mechanisms, such as activation of the oxytocin system may partly explain this reduction of psychological stress for humans who are in contact with animals (Beetz, Uvnäs-Moberg, et al., 2012) (see chapter 2). Although psychological theories of attachment concentrate on attachment between humans, research has demonstrated that children display attachment behaviours towards their pets (Melson \& Fogel, 1989). Because companion animals both give and receive affection, they can
contribute to and partially fulfil attachment needs; therefore, the developmental importance of bonds that children and adolescents form with animals should not be overlooked (Melson, 2003; Melson et al., 1991). In addition, children who develop poor parental attachment tend to nurture internal working models of distrust with others, insecurity, separation anxiety, low self-esteem, and a propensity for loneliness (Bowlby, 1982; Lasgaard \& Elklit, 2009; Raikes \& Thompson, 2008). If children are able to develop secure attachment behaviours with their pets as a substitute, secure internal working models may still develop to some extent (Wedl, Kotrschal, Julius, \& Beetz, 2015).

Companion animals and self-esteem
It has been suggested that if companion animals provide support for self-esteem, their greatest influence will be on youths as they approach adolescence (coinciding with increasing experiences of uncertainty) and at this time they may have a higher need for the emotional support they derive from companion animals (Van Houtte \& Jarvis, 1995). Also, during this period cognitive changes in thinking about the self and others, as well as relationships with significant others, such as parents and peers (and perhaps pets), are most common and can indirectly affect self-esteem (Van Houtte \& Jarvis, 1995). If companion animals provide social support (McNicholas \& Collis, 2001) and act as catalysts for human social interactions (McNicholas \& Collis, 2000), they may reduce loneliness and increase self-esteem. Companion animals have been found to rival and even surpass humans' ability to provide important self-object needs, such as self-cohesion, self-esteem, calmness, soothing, and acceptance (Brown, 2007). Increased self-esteem and self-worth may result in further benefits for individuals with anxiety, depression, behavioural problems and educational attainment.

Companion animals and language
Companion animals may also influence cognitive and language development. It has been suggested that companion animal ownership may facilitate language acquisition and potentially enhance verbal skills in children (Poresky, 1996). This could occur as a result of the companion animal functioning both as a patient recipient of the young child's babble and as an attractive stimulus, eliciting verbal communication from young children in the form of praise, orders, encouragement, and punishment (Poresky, 1996). In addition, although not empirically tested, the pet may also serve as a subject of conversations that stimulate vocabulary building, when caregivers and children talk about what the pet is doing.

Companion animals and cognitive development
Melson (2003) reports evidence that companion animals may stimulate a young child's cognitive growth through curiosity and learning, while also providing emotional support and unconditional positive regard. Melson (2003) stated that for many children, companion animals are likely to be powerful motivators for learning, perhaps due to children learning and retaining more about subjects they are more emotionally invested in, and due to learning being optimized when it occurs within meaningful relationships. The presence of animals has been shown to elicit immediate positive effects in testing situations of cognition such as memory, categorization and attention (Gee, Church, et al., 2010; Gee, Crist, et al., 2010; Gee, De, et al., 2012; Gee, Harris, \& Johnson, 2007; Gee, Sherlock, Bennett, \& Harris, 2009; Hediger \& Turner, 2014) and studies on language, literacy, and reading ability have also shown a similar positive influence of animal presence (Hall, Gee, \& Mills, 2016; le Roux, Swartz, \&

Swart, 2014; O'Haire et al., 2013). It has been speculated that animal interaction may provide opportunities to improve cognitive Executive Functions (EFs) (mental processes that form the basis for planning, attention, memory and self-control) through stress reduction and social support which in turn can affect behaviour and improve academic outcomes (Ling et al., 2016). Thus, it could be plausible that the long-term presence of pets at home will have tangible influences on children's cognitive development and educational outcomes. However, the quality of the existing evidence has not yet been reviewed to infer any conclusions.

Most research to date addressing the impact of pets on human health has focused on adults. Less is known about the role pets play in the lives and wellbeing of children and youths, and if pet ownership may provide scaffolding in child development. As outlined above (and in Chapter 2), there is theoretical potential for the role of pets in child and adolescent development, which suggests these relationships are worth exploring further. However, the existing evidence has not been systematically reviewed to identify particular strengths or gaps in knowledge, nor as to whether causality can be implied. Due to study design and quality, this is a complex task.

Considering that PO also pertains risks, such as zoonoses, bites and asthma/allergies (Voith, 2009), it is important that the impact of pet ownership on childhood development is investigated in detail. Therefore, the objective of this systematic review was to determine the evidence base for the impact of PO and Pet Attachment (PA) on childhood and adolescent development. A broad range of outcomes were reviewed, including emotional, behavioural, cognitive, educational and social developmental. Recommendations for future research are provided to help advance the field of child development and HAI research.

### 3.2 Method

Searches
Literature searches of journal articles published between 1960 and 2018 (as of 1 December 2018) were conducted in databases PsycINFO, CINAHL, PubMed, MEDLINE, Web of Science, ScienceDirect and grey literature sources.

Key terms used in searches included pet-related keywords (pet, pet ownership, dog, cat, dog ownership, companion animal, and human animal interaction) and were crossed with developmental-related keywords (child development, adolescent development, psychological, behavioural, educational, cognitive, language and social development, anxiety, depression, self-esteem, loneliness, emotional health). Websites on human-animal interaction were reviewed for possible research articles, including https://www.waltham.com/waltham-research/hai-research/
and https://habricentral.org/resources/browse/journalarticles. In addition, reference lists from relevant journal articles were scanned. It is still possible that evidence remains in unfound grey literature.

## Inclusion criteria

The inclusion criteria for the collection of articles included: literature that investigated the effects of pet ownership on emotional, cognitive or behavioural development in children and adolescents without developmental disabilities (infancy up to 18 years). Only articles written in English were included. With the aim of carrying out a broad review of the current relevant literature, restrictions for inclusion were limited; papers were not excluded based on study design and methodology.

Review
Initially, abstracts were reviewed for study selection by the primary author. Research excluded on the basis of content and deemed not relevant to the aim of this paper included Animal Assisted Therapy (AAT), therapy and classroom animals, pets and their effect on physical health (asthma/allergy or other chronic illnesses), ethical and moral development.

The studies were then assessed by the primary author against the OCEBM (Oxford Centre for Evidence-Based Medicine) levels of evidence 2011 (OCEBM, 2011) to take into account the risk of bias and quality of evidence on which conclusions are based, although no study was excluded based on quality alone due to large gaps in current evidence and poor availability of good-quality studies within each outcome (refer to Tables 1 and 2 for details of classification).

Table 1. Oxford Centre for evidence-based medicine 2011 levels of evidence.
Level of Evidence Description

Level I Systematic review of Randomized Controlled Trials
Level II Randomized Trials
Level III Non-randomized controlled cohort/follow-up studies
Level IV Case-series, case-control studies
Level V Expert opinion/Mechanism-based reasoning
Level I = highest evidence (lowest potential for bias);
Level $\mathrm{V}=$ lowest evidence (greatest potential for bias).

### 3.3 Results

Search results
The initial literature searches returned 2962 results. Grey literature searches found an additional 11 references totaling 2973 publications (Figure 1). Forty-four publications remained after the examination of studies against the inclusion criteria. After removing duplicates and the studies not fitting the criteria, 25 studies remained for review.


Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

Among the selected studies, which commonly reported on more than one outcome, 20 reported on the effects of PO on emotional health, six on behavioural development, three on cognitive development, four on educational outcomes, and four on social development. Of the 25 studies, 15 reported cross-sectional data and only three reported longitudinal data on the impact of pets on youth development; a further one used mixed methods, and six qualitative studies were included.

## Evidence of bias

Bias was determined based on the Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence criteria (OCEBM, 2011). OCEBM levels of evidence rankings were as follows: twenty-two papers were ranked level 4, and three papers were ranked at level 3. Specific details of the literature can be found in Table 2. The majority of the studies were observational cross-sectional questionnaire surveys, or qualitative interviews, therefore were not further evaluated on their methodological quality as they are already considered low or very low levels of evidence according to OCEBM 2011. Refer to Figure 2 for a graphical representation of study design and risk of bias. Meta-analysis was not appropriate due methodological differences and the number of different outcomes reported.


## KEY

Each bar represents a study, referenced by number. Key study characteristics are represented by the following:


Figure 2. Harvest plot showing evidence for the impact pets have on categories of child and adolescent development. The table consists of eight rows (one for each dimension of development) and three columns (showing the differential effects of the evidence in each category). Each study is represented by a bar in each row; studies can be identified by reference number. Statistical significance reported (reported $p$-values) are indicated with solid blue bars, and studies with no confidence intervals and $p$-values reported are striped bars. The quality of study design is indicated by the height of the bar as categorised by OCEBM level of Evidence 2011. Each bar is annotated with marking to show risk of bias.

Table 2. Evidence for the impact pets have on child and adolescent development.

| Reference | Topic | First Author (Year) | $\begin{gathered} \hline \text { OCEBM } \\ \text { Level } \\ (2011) \\ \hline \end{gathered}$ | Type of Animal | Sample Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 <br> (Rhoades, <br>  <br> Rice, 2015) | Emotional health <br> (depression) | Rhoades (2015) | IV | $\begin{gathered} \text { Dog ( } 53 \% \text { ), } \\ \text { cat }(22 \%), \\ \text { hamster, } \\ \text { rat, } \\ \text { chinchilla, } \\ \text { fish, iguana } \\ \hline \end{gathered}$ | 332 | $\begin{gathered} 13 \\ \text { years } \end{gathered}$ | 91 female 234 male | Crosssectional survey Control group used. | Yes | Pet owning homeless youths reported fewer symptoms of depression and loneliness than their non-pet owning peers. |
| $\begin{gathered} \mathbf{1} \\ \text { (Gadomski et } \\ \text { al., 2015) } \end{gathered}$ | Emotional health/behav ioural/social/ cognitive development | $\begin{gathered} \text { Gadomski } \\ (2015) \end{gathered}$ | IV | Dog | 643 | $\begin{gathered} 4-10 \\ \text { years } \end{gathered}$ | 289 <br> female <br> 354 <br> male | Cross- <br> sectional survey <br> Control group used | Yes | Having a pet dog in the home was associated with a decreased probability of childhood anxiety in some components (panic, social and separation anxiety) of the SCARED-5 (Screen for Child Anxiety Related Emotional Disorders). However, no difference was found between dog owning and non-dog owning children in their histories of mental health problems. Nor were there significant effects of pet ownership in childhood social, emotional, and behavioural development. |
| 2 <br> (Vidović, Štetić, \& Bratko, 1999) | Emotional health (loneliness, attachment, social anxiety) | Vidovic (1999) | IV | $\begin{gathered} \text { Dog } \\ (26.2 \%) \text { Cat } \\ \text { (9.2\%) } \\ \text { Other } \\ (19.0 \%) \end{gathered}$ | 826 | $\begin{aligned} & 10-15 \\ & \text { years } \end{aligned}$ | 425 <br> female <br> 401 <br> male | Crosssectional, correlational design Control group used | No | Children who scored higher than average on the attachment to pets scale showed significantly higher scores on empathy and prosocial orientation scales. Pet owners, regardless of age, were not significantly lonelier than non-owners, nor were they socially more anxious. |


| Reference | Topic | First <br> Author <br> (Year) | $\begin{gathered} \hline \text { OCEBM } \\ \text { Level } \\ (2011) \\ \hline \end{gathered}$ | Type of Animal | Sample Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (Mathers, Canterford, Olds, Waters, \& Wake, 2010) | Emotional health | Mathers (2010) | III | Dog, Cat, <br> Horse or Pony and Other | 928 | $\begin{aligned} & 13-19 \\ & \text { years } \end{aligned}$ | 460 <br> female <br> 466 <br> male | Crosssectional data from longitudinal school-based population study | Yes | Neither owning a pet nor time spent caring for/playing with a pet appeared to be related to better adolescent emotional health, social development or well-being. Neither did they contribute to negative outcomes. These findings may not apply to other (younger) age groups with a typically higher level of interaction with their pets. |
| $\begin{gathered} 15 \\ \text { (Rew, 2000) } \end{gathered}$ | Emotional health (loneliness) | $\begin{aligned} & \text { Rew } \\ & (2000) \end{aligned}$ | IV | All | $\begin{aligned} & 32 \\ & 10 \end{aligned}$ | $\begin{aligned} & 16-23 \\ & \text { years } \\ & 15-23 \\ & \text { years } \end{aligned}$ | 14 female 18 male 3 female 6 male 1 "both" | Qualitative focus groups Qualitative interviews | No | Dogs or animal companions are used as a coping strategy for loneliness. Vulnerable adolescents who are homeless often recognize the therapeutic value of pets. |
| $\begin{gathered} 16 \\ \text { (Black, 2012) } \end{gathered}$ | Emotional health (loneliness, social support) | $\begin{aligned} & \text { Black } \\ & \text { (2012) } \end{aligned}$ | IV | Dogs (67\%), Cats (18\%), Horses (5\%) <br> Rodents and Reptiles (10\%) | 293 | $\begin{aligned} & 13-19 \\ & \text { years } \end{aligned}$ | 158 female 135 male | Cross- <br> sectional <br> survey <br> Control group used | No | High school student pet owners reported less loneliness than non-pet owners. Companion animal attachment was positively related to the numbers in the social support network. |


| Reference | Topic | First <br> Author <br> (Year) | $\begin{gathered} \hline \text { OCEBM } \\ \text { Level } \\ (2011) \\ \hline \end{gathered}$ | Type of Animal | Sample Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4 <br> (Arambašić, KuterovacJagodić, \& Vidović, 1999) | Emotional health (selfesteem) | Arambasi c (1999) | IV | Dog, cat and other (birds, fish, rodents and turtles) | 612 | $11-15$ <br> years | 311 <br> female <br> 301 <br> male | Cross- <br> sectional <br> survey <br> Control <br> group used | Yes | Pet ownership had no significant impact on the self-esteem of war-traumatized children. Self-esteem of pet owners did not differ from self-esteem of non-pet owners, and the type of pet owned also had no effect on self-esteem. |
| 9 <br> (Van Houtte \& Jarvis, 1995) | Emotional health (selfesteem, selfconcept) | Van <br> Houtte <br> (1995) | IV | All | 130 | $\begin{gathered} 8-13 \\ \text { years } \end{gathered}$ |  | Crosssectional survey Control group used | Yes | Higher self-esteem was reported in pet owners than in non-pet owners, as was a higher autonomy, and self-concept. Attachment to animals was not found to be higher in the pet-owning group and greater attachment to animals was not found to be related to higher scores on the dependent measures. |
| $\begin{gathered} 12 \\ \text { (Bryant, 1990) } \end{gathered}$ | Emotional health (selfesteem) | Bryant (1990) | IV | All | 213 | $\begin{gathered} 8-13 \\ \text { years } \end{gathered}$ | Not reported | Qualitative interviews Principal component factor analysis | No | Children felt their companion animals benefited them in 4 factors: (1) mutuality (reciprocity in the caring and loving between pet and child); (2) enduring affection (even if the child misbehaves the pet will still love him or her); (3) selfenhancing affection (the child-pet relationship is perceived by children as one that makes them feel good about themselves and imparts a sense of importance) and (4) exclusivity of the childpet relationship |


| Reference | Topic |  | $\begin{gathered} \hline \text { OCEBM } \\ \text { Level } \\ (2011) \\ \hline \end{gathered}$ | Type of Animal | Sample Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} 8 \\ \text { (Triebenbache } \\ \text { r, 1998) } \end{gathered}$ | Emotional health (selfesteem) | Triebenba cher (1998) | IV | All | 436 | $\begin{aligned} & 9-18 \\ & \text { years } \end{aligned}$ | 204 <br> female <br> 232 <br> male | Cross- <br> sectional <br> survey <br> Control group used | No | No direct relationship between levels of self-esteem and pet ownership in school children. An indirect relationship was found between pet ownership and selfesteem mediated by attachment to companion animals. As with other components of psychological health, there may be a relationship between levels of attachment to one's pet and self-esteem benefits accrued. |
| 13 <br> (McNicholas \& Collis, 2001) | Emotional health (selfesteem/social support) | McNichol as (2001) | IV | All | 22 | $\begin{gathered} 7-8 \\ \text { years } \end{gathered}$ | 9 female <br> 13 male | Qualitative interviews | No | Pets were often ranked higher than certain kinds of human relationship, and featured prominently as providers of comfort, esteem support and confidantes for a secret. Dogs and cats offer special relationships for provision of psychological forms of support but not for the more practical problems a child might have to deal with. The fact that cats and dogs frequently ranked higher than many human relationships suggests the value that children place on their pets and the functions they serve. |


| Reference | Topic |  | $\begin{gathered} \hline \text { OCEBM } \\ \text { Level } \\ (2011) \\ \hline \end{gathered}$ | Type of Animal | Sample <br> Size | Age | Gender | Study Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} 5 \\ \text { (Paul \& } \\ \text { Serpell, 1996) } \end{gathered}$ | Emotional health (confidence, tearfulness, self-esteem) | $\begin{gathered} \text { Paul } \\ (1996) \end{gathered}$ | III | Dog | 56 | $\begin{gathered} 8-12 \\ \text { years } \end{gathered}$ |  | Prospective questionnair e survey Control group used | Yes | Higher levels of attachment to the dog were positively associated with changes in confidence by the 6 month follow-up, and negatively associated with changes in tearfulness or weepiness by the 12 month follow-up. The positive association between dog attachment and subject children's confidence (at the 6 month follow-up) and its negative association with tearfulness (at the 12 month follow-up) were consistent with the findings of previous studies which suggest that pet keeping can be associated with higher levels of self-esteem |
| 11 (Covert et al., 1985) | Emotional health (selfesteem/stress) | Covert <br> (1985) | IV | All | 285 | $\begin{aligned} & 10-14 \\ & \text { years } \end{aligned}$ | Not reported | Qualitative <br> Interview <br> Mixed <br> methods | No | Early adolescent animal owners had higher self-esteem than non-animal owners. <br> Adolescents felt they gained responsibility (rabbit/hamster), and friendship/love/fun (dog, horse and fish/bird) from pet ownership. Early adolescents used pets for stress reduction. |
| 10 <br> (Poresky, Hendrix, Mosier, \& Samuelson, 1988a) | Emotional health (selfconcept) | Poresky (1988) | IV | All | 188 | 14-49 <br> years | 99 <br> female 89 male | Crosssectional survey | No | Self-concepts of undergraduates were related to the age when they had their first pet. Total Positive Self-Concept scores were higher if participants were under 6 years or over 10 years old than if they were between 6 and 10 years old when they had their 1st pet. |


| Reference | Topic | First <br> Author <br> (Year) | $\begin{gathered} \text { OCEBM } \\ \text { Level } \\ (2011) \end{gathered}$ | Type of Animal | Sample <br> Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 14 <br> (Winsor \& Skovdal, 2011) | Emotional health (selfconcept and psychosocial development) | Winsor (2011) | IV | Goat | 15 | $\begin{aligned} & 12-17 \\ & \text { years } \end{aligned}$ | 7 female <br> 8 male | Qualitative interviews | No | Goat ownership enabled children to create positive images of self and life-deriving emotional benefits. Goat ownership provides orphaned and vulnerable children with opportunities for positive social participation and community engagement that can facilitate children's resilience and wellbeing. |
| $\begin{gathered} \mathbf{6} \\ \text { (Davis, 1987) } \end{gathered}$ | Emotional health (psychosocial development) | Davis (1987) | IV | Dog | 22 | $\begin{aligned} & 10-12 \\ & \text { years } \end{aligned}$ |  | Cross- <br> sectional survey | No | Reasons for acquiring a dog centered on the companionship and emotional dimensions <br> of pet ownership. It appears that the preadolescent does not actually assume a large proportion of daily, routine pet care responsibility, instead they acquire a pet dog for companionship and emotional dimensions of pet ownership. |
| $\begin{gathered} 18 \\ \text { (Maruyama, } \\ 2011 \text { ) } \end{gathered}$ | Cognitive development | Maruya ma (2011) | IV | All | 65 | $\begin{aligned} & 10-14 \\ & \text { years } \end{aligned}$ |  | Mixed methods Crosssectional survey Qualitative interviews | No | Students who showed stronger attachment with their pets had higher levels of social cognitive development than students who showed weaker attachment with their pets. <br> Students whose parents show more effective guidance on pet care have more advanced skills of thinking and solving problems in flexible manner than students who do not receive any or less guidance on pet care at home. |


| Reference | Topic | First <br> Author <br> (Year) | $\begin{gathered} \text { OCEBM } \\ \text { Level } \\ (2011) \end{gathered}$ | Type of Animal | Sample Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 20 <br> (Geerdts et al., 2015) | Educational (biological knowledge/ psychological reasoning) | Geerdts (2015) | IV | Dog and Cat | $\begin{aligned} & 24 \\ & 96 \end{aligned}$ | $\begin{gathered} 2-6 \\ \text { years } \end{gathered}$ |  | Observations , crosssectional survey and experimental tasks | No | Both 3 and 5-year-olds with pets were more likely to attribute biological properties to animals than those without pets. Both older and younger children with pets showed less anthropocentric patterns of extension of novel biological information. The results suggest that having pets may facilitate the development of a more sophisticated, human-inclusive representation of animals. |
| 21 <br> (Prokop, Prokop, \& Tunnicliffe, 2008) | Educational (biological knowledge) | Prokop (2008) | IV | All | 1541 | $\begin{aligned} & 6-15 \\ & \text { years } \end{aligned}$ | 753 <br> female <br> 788 <br> male | Experimental task | Yes | Experiences with rearing pets significantly contributed to children's knowledge about animal's internal organs. Children who reported keeping 2 or more animals acquired better scores than children keeping only 1 or no animals. |
| $\begin{gathered} 22 \\ \text { (Svensson, } \\ \text { 2014) } \end{gathered}$ | Educational/ <br> Emotional health | $\begin{gathered} \text { Svensson } \\ (2014) \end{gathered}$ | IV | Dog and Cat | 24 | $\begin{gathered} 4-5 \\ \text { years } \end{gathered}$ | 12 <br> female <br> 12 male | Qualitative interviews | No | The pet supports the child in the learning and development process by (l) Developing empathy and emotions; (2) Being good at school-related tasks. Pets provide children with positive experiences and a sense of feeling good. |


| Reference | Topic | First <br> Author <br> (Year) | $\begin{gathered} \hline \text { OCEBM } \\ \text { Level } \\ (2011) \\ \hline \end{gathered}$ | Type of Animal | Sample <br> Size | Age | Gender | Study <br> Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (Poresky \& Hendrix, 1989) | Social <br> development/ educational/ cognitive development | Poresky (1989) | IV | All | 88 | $\begin{gathered} 3-6 \\ \text { years } \end{gathered}$ | Not reported | Crosssectional survey /interview | Yes | Developmental benefits were primarily in the children's social domain including social competence, empathy, and pet attitudes. "Pet bonding" appeared to be a stronger determinant of the pet associated benefits than "pet ownership. Children with companion animals and a better home environment showed higher age-adjusted child development scores. Intellectual development benefits were also associated with the strength of the bond between the child and his/her pet. Self- reliance and independent decision skills were higher in the children who have pets. |
| $\begin{gathered} 17 \\ \text { (Melson et al., } \\ \text { 1991) } \end{gathered}$ | Socioemotional/ behavioural development | Melson (1991) | IV | All | 120 | $\begin{gathered} 5,7 \\ 10 \\ \text { years } \end{gathered}$ | Not reported | Cross- <br> sectional survey/ individual interview | No | Among kindergarten children, perceived competence was positively and significantly associated with diverse dimensions of attachment to the pet. This was not found in older children. Pet attachment was higher for older children and those whose mothers were employed. |


| Reference | Topic | First <br> Author <br> (Year) | OCEBM <br> Level <br> (2011) | Type of <br> Animal | Sample <br> Size | Age | Gender | Study <br> Design | Confounding <br> Considered? | Outcome |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |


| 23 | Emotional | Reis | IV | All | 6026 | $11-16$ <br> (Reis et al., | Hears | $52.3 \%$ | Population |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| female | based survey |  |  |  |  |  |  |  |  |$\quad$ Yes

Pets elicited feelings of happiness, companionship, nurturing, tranquility, security and responsibility always/almost always, especially in girls and younger boys. The results also showed that having a dog was associated with a higher socioeconomic status, better perception of well-
being, more life satisfaction and less
psychological symptoms.
Unadjusted analyses found that children in pet-owning households were significantly 24

| (Miles, Parast, Babey, | Emotional and | Miles (2017) | III | Dog and | $5,191$ <br> househo | $5-11$ | $49 \%$ | Population | Yes |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Griffin, \& | behavioural | (2017) |  |  |  | years |  | based survey |  |
| $\begin{gathered} \text { Saunders, } \\ 2017) \end{gathered}$ | health |  |  |  |  |  |  |  |  | healthier than children in non-owning households (less concern from parents regarding mood, behaviour, and learning ability). However, when estimates were adjusted for confounders the effects were smaller and no longer statistically

The initial effect of pet ownership on delinquent behaviour and depressed mood became non-significant once controls for gender, age, minority race/ethnicity, and family socioeconomic status were considered. Pets prosocial behavior effects were only slightly attenuated and remained statistically significant.

## Emotional Health Outcomes

Twenty of the 25 studies were devoted to children's emotional health. A wide range of emotional health benefits from childhood pet ownership were identified.

### 3.3.1 Anxiety

Two studies measured anxiety as an outcome in youth pet ownership. Having a pet dog was associated with a decreased likelihood of general anxiety ( $12 \%$ of children with dogs met the clinical cut-off value for anxiety compared with $21 \%$ children without dogs) as measured by commonly used and validated mental health assessment tools, specifically Panic ("My child gets really frightened for no reason at all"), Separation Anxiety ("My child is afraid to be alone in the house") and Social phobia/anxiety ("My child is shy"), in an American study of children aged 4-10-years in a paediatric primary care setting (Gadomski et al., 2015). However, no evidence of a difference was found for Generalized Anxiety ("People tell me that my child worries too much") and Significant School Avoidance ("My child is scared to go to school"). In adolescents, we see similar results; those who reported having a dog showed significantly less psychological symptoms (fear and nervousness) than adolescents who reported having a cat, a dog and a cat, and having other pets ( $p<0.023$ ) (Reis et al., 2018). In contrast, in a Croatian study of 10-15-year-old children, pet owners (dog and cat) had no difference in validated social anxiety measures compared to non-pet owners (Vidović et al., 1999). In sum, these studies illustrate some potential of pet dogs to prevent child and adolescent anxiety, specifically separation and social anxiety disorders, but the small number of studies and mixed results warrant further research. Whether pets can reduce more general child anxiety is unknown.

### 3.3.2 Depression

There is again a marked lack of research focusing on the effects of pet ownership on depressive symptoms in children and adolescents.

In one study, pet owning homeless adolescents utilizing two Los Angeles drop-in centres reported fewer symptoms and lower average scores of self-reported depression measured by the 10 -item Centre for Epidemiological Studies Depression Scale (CESD) (average score of 7.8) in comparison to non-pet owning peers (10.2) (Rhoades et al., 2015). However, data from an Australian school-based population study show petowning youths of similar ages (13-19 years) did not have better self-reported emotional health or well-being, suggesting findings may be different in non-homeless youths (Mathers et al., 2010).

The potential protective effects of pets may also differ by age group. Prospective research in 8-12-year-olds found that high levels of attachment to a pet dog were negatively associated with maternal reports of tearfulness and weepiness at a 12 month follow up ( $p<0.01$ ) (Paul \& Serpell, 1996). In slightly older children we see similar results; adolescents who reported having a dog showed significantly less psychological symptoms (sadness/depression) than adolescents who reported having a cat, a dog and a cat, and having other pets ( $p<0.023$ ) (Reis et al., 2018). However, the impact of dog ownership on depressive symptoms in younger children measured by the Pediatric Symptom Checklist 17 (internalizing symptoms subscale) showed no significant effects, and in addition no difference was found between dog-owning and non-dogowning children in their histories of diagnosed mental health problems (Gadomski et al., 2015). Therefore, it could be speculated that the relationship with the animal may be of more importance in conferring psychological benefits than pet ownership alone. Alternatively, two recent studies found that any effect pets had on low mood became
attenuated after the adjustment of sociodemographic factors (Jacobson \& Chang, 2018; Miles et al., 2017).

### 3.3.3 Self-esteem

Nine studies investigated the impact of pets on the self-esteem and self-concept among youths. No effect on self-esteem was found in pet-owning war-traumatized children (11-15 years) in Croatia using the Croatian Version of Rosenberg's Self Esteem Scale (Arambašić et al., 1999). In the same study, the type of pet owned had no effect either on validated self-esteem measures. In a different study of school children aged 9-18 years, children's attachment to pets mediated the relationship between self-esteem as measured using validated self-report measures (Triebenbacher, 1998). Therefore, there may be a relationship between the level of attachment to one's pet and self-esteem benefits accrued. In addition, prospective research found (using maternal reported data) that higher levels of children's (8-12 years) attachment to a pet dog were positively associated with changes in their confidence level ( $p<0.005$ ) over a 6 month period (Paul \& Serpell, 1996).

In contrast, in a mixed-methods study of children aged 10-13 years, pet owners in fifth $(\mathrm{m}=16.7)$ and sixth grade $(\mathrm{m}=17.2)$ reported higher levels of self-esteem than non-pet owners $(\mathrm{m}=20.0, \mathrm{~m}=20.8)$ (lower mean indicative of greater selfesteem) ( $p<0.04$ ) and pet owning sixth graders had higher self-concept scores in comparison to non-pet owners in the same grade (pet owners: $\mathrm{m}=94.2$, non-pet owners: $\mathrm{m}=83.2$ ) $(p<0.001)$ (Van Houtte \& Jarvis, 1995), even though greater attachment to pets was not related to self-esteem or self-concept. However, in the same study, children aged 8-10 did not differ in terms of self-esteem compared to non-pet owners, suggesting that pets exert their greatest influence during pre-adolescence and
adolescence (Van Houtte \& Jarvis, 1995). Other studies also indicate that PO alone is sufficient to have a positive effect on self-esteem or self-concept, independent of PA. Among 8-13-year-olds, qualitative research supports the finding companion animals increase child and adolescents self-esteem and self-enhancing affection-the perception that the child-pet relationship imparts a sense of self-importance and makes them feel good about themselves (Bryant, 1990). Further qualitative data supports this. In a study of 7-8-year-old children examining representations of social support from companion animals using a story-based methodology, relationships with pets were ranked higher than human relationships by children as providers of both self-esteem and support (McNicholas \& Collis, 2001). Generally, dogs and cats were deemed better providers of psychological support as they consistently achieved higher rankings than many of the child's human relationships, such as making one feel better about oneself, but not for practical problems children may have to face.

Furthermore qualitative study of early adolescents (10-14 years) found pet owners to have enhanced self-esteem amongst other pet-owning benefits such as friendship and stress reduction (Covert et al., 1985). Importantly, a long term effect may be present; the self-concept of undergraduate students (14-49 years) was related to the age they were when they had their first pet (Poresky et al., 1988a). Scores were higher if participants were in early childhood (below 6 years old) ( $\mathrm{m}=349.42$ ) or in adolescence (over 10 years old) ( $\mathrm{m}=361.81$ ), than if they were in middle childhood (between 6 and 10 years old) $(\mathrm{m}=342.14)$ when they owned their first pet.

The psycho-social wellbeing of youths due to goat ownership has been examined in Western Kenyan culture. A qualitative study using thematic analysis found that after orphaned 12-17-year-old children were given goats to care for, the development of pride, self-concept and self-worth was much improved due to goat ownership (Winsor
\& Skovdal, 2011). Owning goats, which are typically kept as property rather than pets, enabled children to create positive images of the self and of life, increased resilience and coping skills and increased social participation within the community. However, it must be recognised that goat ownership in this case may imply an increase in wealth therefore, child welfare may not have been directly affected by interaction with the animals, but instead by an escape from poverty.

### 3.3.4 Loneliness

Loneliness is likely a precursor for anxiety, depression and low self-esteem. There is some evidence that pet ownership may protect youths from loneliness and social isolation, and therefore may help to prevent depression. Pet-owning homeless youths aged 15-23 years reported fewer symptoms of loneliness both quantitatively (UCLA Loneliness Scale score of 1.8, compared to 2.3 among non-pet owners) (Rhoades et al., 2015) and qualitatively (Rew, 2000) than their non-pet owing peers in addition to reduced symptoms of depression. A large proportion of these youths had pet dogs (53\%) and other companion animals, which they recognized as a coping strategy for loneliness due to their therapeutic nature and value (Rew, 2000).

The protective impact of PO on loneliness has also been observed in less vulnerable populations. For example, high school students (13-19 years) who owned a pet reported significantly lower scores of loneliness (mean score of 33.7) than nonpet owners (39.5) using validated scales (Black, 2012), regardless of ethnicity, gender, age, and family composition. In addition, loneliness scores were not affected by length of relationship with the pet or the number of pets owned. Companion animal attachment was positively related to the number of humans in the students' social support network, suggesting that PA may play an important role as a predictor.

However, another study using validated measures of socio-emotional development of children aged 10-15 years found that pet owners were no more or less lonely than nonpet owners, although they did show a high degree of emotional closeness to their pets (Vidović et al., 1999). The impact of PO on loneliness in younger children has not been investigated.

### 3.3.5 Behavioural

There is mixed evidence on whether PO affects behavioural outcomes in children or adolescents as shown in Figure 2. Amongst U.S. kindergarten children aged 5 years, perceived competence (cognitive competence, physical competence, peer acceptance and maternal acceptance) measured by parental report, was positively associated with PA (Melson et al., 1991). However, in the same study among older children (7 years and above), attachment to pets and perceived competence were generally unrelated. In a UK prospective follow up study, mixed equivocal findings were demonstrated in middle childhood ( $8-12$ years). Findings suggest that behaviour improves when families first acquire a pet dog, but does not differ from non-dog-owning children longitudinally; dog owning children were reported to be less naughty, less argumentative, better behaved, and more co-operative by their mothers at the 1 month follow-up after acquiring a pet dog than non-dog owners, but there were no differences thereafter at the 6 and 12 month follow ups (Paul \& Serpell, 1996). In addition, and perhaps surprisingly, caring behaviour was reported to decrease in dog-owning children in that study; however, it was not specified who, pets or humans, were the recipients of the caring behavior. Similarly, an American study of children in a paediatric primary care setting found no differences in the behaviour of dog owning children and non-dog owners aged 4-10 years measured by the Strengths and

Difficulties Questionnaire (SDQ) (Gadomski et al., 2015). Furthermore a Californian population based study found coefficient estimates for the pet effect on obedient behavior became attenuated after adjusting for sociodemographic confounding factors (Miles et al., 2017), and similarly, another study found the association between PO and delinquent behavior to disappear after adjustment of confounding factors (Jacobson \& Chang, 2018). In contrast, four other studies demonstrated how PO increased behaviours of responsibility. The majority of adolescents (56.4\%) reported owning pets as giving them responsibility (Reis et al., 2018). Qualitative data from homeless youths suggests that dogs provide the opportunity to be responsible and care for another being, which in turn promoted healthier self-care choices and decisionmaking, for example, less alcohol consumption and improved financial choices (Rew, 2000). Finally, a significant main effect was found ( $p=0.006$ ) for pet owners aged $8-$ 13 years old showing greater autonomy (third grade $\mathrm{m}=13.3$, fourth grade $\mathrm{m}=13.8$, fifth grade $\mathrm{m}=14.6$, sixth grade $\mathrm{m}=14.9$ ) than non-pet-owning children (third grade $\mathrm{m}=14.9$, fourth grade $\mathrm{m}=16.0$, fifth grade $\mathrm{m}=16.0$, sixth grade $\mathrm{m}=15.8$ ) (lower mean indicative of greater autonomy). Explicitly, pet-owning individuals were more able to see their parents in roles other than the parental role and thus were deemed as more autonomous than non-pet owners (Van Houtte \& Jarvis, 1995). The study suggested that PO has the potential to foster the development of autonomous characteristics such as responsibility and self-reliance (Van Houtte \& Jarvis, 1995).

### 3.3.6 Cognitive

Three studies have addressed the impact of PO on child and/or adolescent cognitive development. A mixed methods thesis paper found that $10-14$-year-old students with a stronger attachment to their pets had higher levels of validated socialcognitive development scores, for example in perspective-taking abilities, in comparison to students with a weak attachment to their pets ( $p<0.001$ ) (Maruyama, 2011). However, no comparisons with non-pet owners were made. Pet care guidance, measured by survey questionnaire ('How do you guide your child when s/he forgets to take care of the pet?') also played a role; in the same study, students whose parents displayed more effective guidance of pet care showed stronger attachment with their pets $(m=28.19)$ than students who received less or no parental guidance on pet care at home ( $\mathrm{m}=14.28$ ), and had more advanced skills of cognition and flexible problemsolving than students who received little or no guidance ( $p<0.05$ ) (Maruyama, 2011). However, in a cognitive subscale of Attention (Pediatric Symptom Checklist 17) no differences were found when comparing dog-owning children to non-dog owners aged 4-10 years (Gadomski et al., 2015). Lastly, research on companion animal bonding and young children's social development found higher scores on parent reports of selfreliance and independent decision skills in strongly bonded pet-owning children compared to weak and moderately bonded pet-owning children, and non-pet-owning children ( $p<0.05$ ) (Poresky \& Hendrix, 1989).

### 3.3.7 Educational

Four studies examined the impact of pets on educational outcomes. Pets may be useful in the engagement of both verbal and physical reciprocal behaviours. In a study investigating the effects of exposure to animals on children's biological concepts, $2-$ 6-year-old children with pets were more likely to attribute biological properties to animals than those without pets, and showed less anthropocentric patterns of extension of novel biological information, suggesting that having pets increases children's knowledge of biology (Geerdts et al., 2015). Thus, PO could facilitate the development of a more sophisticated, human-inclusive representation of animals in children (Geerdts et al., 2015). Similarly, 6-15-year-old children who owned two or more pets scored better on factual knowledge of animal anatomy than non-pet owners (Prokop et al., 2008). Furthermore, a Swedish study including qualitative interviews regarding the impact of pets on children's development and desire to learn ("what can you learn from your pet?" and "What can your pet teach you?") showed that owning dogs and cats may facilitate 4-5-year-old children's learning and development process. Specifically, PO aided the learning process in two sub-categories: 1. Developing empathy and emotions, and 2. Being good at school-related tasks (Svensson, 2014). Pets provided children with positive experiences and a sense of feeling good whilst increasing their knowledge of social behaviour. Exemplified sentiments expressed by many children in this study state "an animal listens only to you and gives you their full attention". Such attention, in turn, may give children a sense of importance, satisfaction and a desire to learn more (Svensson, 2014). Finally, an early study of receptive vocabulary skills found bonding with a pet among 3-6-year-old children resulted in higher verbal intelligence scores in children moderately bonded to their pets ( $\mathrm{m}=124.20$ ) in comparison to non-pet-owning children $(\mathrm{m}=111.25)$ (Poresky \&

Hendrix, 1989). No research has been carried out to investigate the impact of PO on later adolescent educational outcomes.

### 3.3.8 Social development

The role of PO and bonding with a pet among the social development of 3-6 year old children has been evaluated by parental reports (Poresky \& Hendrix, 1989). It was concluded that young children derive developmental benefits (social competence, empathy, and more positive attitudes toward pets) from their interaction with their companion animals. Bonding with pets appeared to be a stronger determinant of these associations than PO. Taken together, children who bonded well with pets and children with better home environments had higher age-adjusted child development scores.

In contrast, one study showed that PO might actually be detrimental to children's social development, and may even reduce levels of social interaction in some children (Paul \& Serpell, 1996). In a prospective study investigating the effects of obtaining new pet dogs, children's attachment to pets at the 12 month follow up was associated with increases in the amount of time spent alone between baseline and 12 months ( $p<$ 0.05 ), and inversely associated to changes in children's time spent with family ( $p<$ 0.05 ) and friends ( $p<0.05$ ), suggesting a that strong bond with a dog may result in less time spent with others. However, the study does not examine the quality of interactions; it cannot be assumed that quantity of time spent in social relationships with humans alone determines the quality of social interaction. A different study showed no evidence of an impact of dog ownership on social Externalizing outcomes (such as sharing and fighting behaviour, and understanding others feelings) in children aged 4-10 years (Gadomski et al., 2015). Again, no effects of PO on social measures were found in 13-18-year-old adolescents measured by the Pediatric Quality of Life

Inventory which assesses social functioning and psychosocial health summary scores (Mathers et al., 2010).

### 3.4 Discussion

The impact of PO on child and adolescent development is a promising area of research but current evidence base does not permit firm conclusions to be drawn. This chapter provides a review of the evidence on the effects of PO on emotional, behavioural, cognitive, educational and social development. Overall, the evidence suggests that PO, and dog ownership in particular, may benefit these outcomes for children and adolescents. However, the evidence is mixed partly due to a broad range of different methodological approaches and varying quality of studies. In regards to the quality of the studies, the majority of the literature is categorised at low levels (Level 3 and 4) on the OCEBM criteria (OCEBM, 2011). In addition, small samples sizes are common, and confounding factors have not always been accounted for. Therefore, the findings from which conclusions are drawn should be interpreted with caution.

## Hypothesized Conceptual Diagrams

Diagrams have been conceptualized for the plausible relationships between PO and children's emotional, behavioural and cognitive outcomes (Figures 3-5). I have attempted to focus these hypothesized diagrams strongly on the links found in the current literature within the field. The mechanisms behind these developmental processes are likely to be much more complex however, they were simplified to focus on the plausible links found in this review, and for ease of interpretation. In addition, it is important to take into account the methodological issues, mixed results, and lack
of replication of the literature used to postulate these hypothesized mechanisms. High quality research is needed to determine specific effects in pet type and child age, and to further explore if these links are truly causal. What follows is a brief summary of the results along with supporting research, followed by gaps in the literature and suggestions for further research directions.


Figure 3. Hypothesized links for the impact of PO and PA on emotional health outcomes that postulates (a) physiological responses from pet interaction result in stress reduction (green pathway), and (b) anxiety, separation anxiety and depression are indirectly reduced by a wider social network and increased social support and companionship from pets (blue pathways) and (c) pet attachment may be indirectly affected by primary caregiver attachment (mother figure) through the internal working model (red pathway).


Figure 4. Hypothesized links for the impact of PO and PA on self-esteem, and loneliness that postulates (a) pet attachment directly increases selfesteem, and self-esteem and self-concept are increased indirectly through a wider social network resulting in increased social support (green) and (b) loneliness is reduced through a wider social network gained from having a pet, and increased social support and companionship from the pet (blue) and (c) relationship and communication skills are honed through increased social interaction (red).


Figure 5. Hypothesized links for the impact of PO and PA on cognitive and educational outcomes, that postulates (a) Executive Functions are indirectly supported by stress reduction and increased social support, and therefore a
reduced incidence of problematic behaviours follows (green) and (b) improved academic outcomes may result due to education being positively affected by improved executive functions and increased social support (blue) and (c) social cognition and language acquisition are enhanced by communication and social interaction with pets (red).

### 3.4.1 Emotional Health

Overall, current evidence suggests that pet dogs may be beneficial in terms of preventing separation anxiety and social anxiety in both children and adolescents (Gadomski et al., 2015; Wright et al., 2015), however, this requires further investigation, as this finding is not consistent in older children and adolescents (Vidović et al., 1999). It is unknown whether pet dogs can reduce symptoms of anxiety in children. There is little evidence for any effects for other pet types. In regards to depression, there is a lack of research investigating the impact of PO in youths, particularly in young children under 8 years old. Similar to anxiety, findings in depression seem to be varied. Findings may differ in younger age groups however, due to a typically higher level of interaction such as pet care and therefore stronger PA (Davis, 1987). This suggests that the nature of the relationship with the animal, rather than simply ownership, may be an important factor in conferring psychological benefits. Overall it is suggested, but not conclusive, that vulnerable adolescents may benefit from pet ownership in terms of reduced depressive symptoms, and children who are attached to their dog during middle childhood may benefit in terms of resilience to depressive emotions in the long term. For young children, pet attachment seems to be a factor of importance for the prevention of depressive symptoms. Findings of the studies included in this review should be interpreted with caution; there
is likely to be an indirect effect of PO on depression, perhaps mediated by self-esteem or loneliness/social isolation.

Within emotional health, the effect of PO on child and adolescent self-esteem is currently the most studied outcome. Research generally demonstrated that children who grow up with companion animals showed higher levels of self-esteem and developed into more socially competent adults than children who do not grow up with companion animals (Endenburg \& van Lith, 2011). Some studies found PA to be a mediator of a relationship between self-esteem and pet ownership (Triebenbacher, 1998); this is supported with longitudinal prospective research (Paul \& Serpell, 1996). Therefore, a relationship may exist between the level of attachment to one's pet and self-esteem levels, similar to other components of psychological health outcomes. However, not all research is consistent with this suggestion; higher self-esteem and self-concept have been reported in pet owners irrespective of PA (Bryant, 1990; Covert et al., 1985; Van Houtte \& Jarvis, 1995) although causation cannot be implied here due to cross-sectional and qualitative study designs. Critical ages for the impact on PO for self-esteem have been suggested (Van Houtte \& Jarvis, 1995); PO may have the greatest influence in children under 6 years old, and preadolescents and adolescents over 10 years old. Lastly, the majority of the evidence suggests that pets are useful in combating loneliness. PA was positively related to the number of humans in their social support network. This suggests pet attachment may again play an important role or, it could be that these people are better at forming attachments in general with humans and/or pets, but again due to study design, causation is not justified. The impact of pets on measures of loneliness in children under 10 years of age has not been investigated.

The significant findings in emotional health are consistent with research involving interaction with dogs as opposed to actual ownership, in 7-12-year-old children with insecure or disorganized attachment in stressful situations (Beetz, Julius, Turner, \& Kotrschal, 2012; Beetz et al., 2011). Dogs caused children's cortisol levels to drop significantly faster and to lower levels after a stressor. It was concluded children with insecure and disorganized attachment may profit more in regulating their physiological stress levels from the interaction with a friendly dog than with a human or toy dog. The data suggest an important role of physical contact in the reduction of stress, although findings on the benefits of physical contact with companion animals are still generally unclear (Gee et al., 2015). Further explanations behind why dog interaction and ownership may have such benefits for anxiety in youths center on the social catalyst effect (Melson, 2011), which states that pet dogs may stimulate conversation and alleviate social anxiety. Hormonal effects may also play a role; companionship and interaction with dogs can also lead to increased levels of oxytocin and reduced levels of cortisol, attenuating physiologic responses to stress and anxiety (Beetz, Uvnäs-Moberg, et al., 2012).

Importantly, child-dog interactions could prevent the evolution of emotional problems into full-fledged mental, emotional or behavioural disorders during adolescence or later life during adulthood (Gadomski et al., 2015), perhaps due to increased emotional support and resilience. This applies in particular to vulnerable (e.g. homeless) youths as companion animals provide emotional support in the form of loving relationships (Rhoades et al., 2015). Furthermore, pet therapy (hospital petvisitation program) has the potential to reduce depressive symptoms and increase mood in children suffering from chronic physical illnesses such as haematological and oncological disorders, cystic fibrosis, diabetes, transplants, and other medical
disorders (Kaminski, Pellino, \& Wish, 2002). Further research is needed as to whether childhood PO may have similar effects.

Both quantitative and qualitative research find self-importance to be a common theme; pets act as a form of psychological support by making youths feel good about themselves and are enabled to create positive images of the self (Bryant, 1990; McNicholas \& Collis, 2001); this also applies to non-western cultures (Winsor \& Skovdal, 2011). These findings are promising and suggest that PO should be investigated as a strategy to increase self-esteem in developing youths. Findings that support this include research carried out using an equine-assisted activity program; although no intervention effect was found on self-esteem, an increase was found in perceived social support in comparison with the control group (Hauge, Kvalem, Berget, Enders-Slegers, \& Braastad, 2014). Animals such as horses and dogs are most likely to increase social circles and the number of human contacts (by creating opportunities to meet others and develop friendships through dog walking, and yard peers), and if so, could increase emotional health outcomes such as self-worth and selfesteem. Overall the current research generally displays potential for pets to increase children and adolescents' resilience and self-worth. In particular, adolescent loneliness and isolation is an important issue, and if untended can manifest as a host of various physical and emotional problems, including anxiety, depression and low self-esteem (Mahon, Yarcheski, Yarcheski, Cannelle, \& Hanks, 2006) and poor academic achievement (Rokach, 2001). Companion animals are used as a coping strategy for loneliness in youths due to their therapeutic nature (Rew, 2000). It is possible that companion animals offer a reciprocal affectionate and non-judgemental relationship, which has obvious benefits for child and adolescent development. Notably, it is difficult to unravel other variables that may explain why pet owning youths seem to
appear less lonely. The importance of parenting styles has previously been suggested (Covert et al., 1985), which may differ in pet owning families, and is likely to increase responsibility, autonomy, empathy and socialization in comparison to non-pet owning households. However, PO may independently impact on the development of empathy and socialization without the influence of parenting style; it is plausible that parents who keep household pets are actually fostering these qualities by proxy (Black, 2012), therefore lessening childhood loneliness. Further well-designed studies are recommended for additional clarity, to infer causality, and to conclude whether there is a link between companion animals and child and adolescent loneliness.

### 3.4.2 Behavioural

The evidence is mixed for the impact of PO on child and adolescent behavioural outcomes. Results of different research studies are not consistent on whether perceived competence in children is positively and significantly associated with PO and/or PA, dependent on age (Melson et al., 1991). There appears to be no long-term behavioural benefit from acquiring a pet dog, as child behaviour only improves when families first acquire the dog (Gadomski et al., 2015; Paul \& Serpell, 1996). Nevertheless, there is literature to suggest that PO and pet care in particular is associated with increases in positive behaviours such as responsibility (Black, 2012; Endenburg \& van Lith, 2011; Mueller, 2014; Rew, 2000; Van Houtte \& Jarvis, 1995). Therefore PO and pet care responsibilities may encourage positive behavioural development in terms of independence, and other autonomous characteristics such as self-reliance (Van Houtte \& Jarvis, 1995). Further well-designed research is needed using objective measures of behaviour, such as school reports. In addition, as child and adolescent behaviour can predict future educational attainment (Sayal, Washbrook, \& Propper, 2015), it would
be interesting to explore the potential links between PO, behavioural outcomes and other indirect developmental relationships. Other non-experimental mechanism-based reasoning reports suggest that pet owning children are likely to show decreased violence and antisocial behaviours, as PO has positive effects on a wide range of developmental outcomes including social and moral development (Güçlü, 2016). However, no evidence of this was found in studies reviewed here. The idea that childhood and adolescent behaviour may predict future antisocial activity is not new. Childhood disruptive behaviour has powerful long-term effects on adult antisocial outcomes, which continue into middle adulthood (Simonoff et al., 2004). If pets can promote such positive behaviour, they may be involved in early interventions. However, there is very little research in the area, and there are findings to argue against this claim; among youth offenders childhood bonding with a pet was not related to antisocial personality traits (Brown, 2000).

### 3.4.3 Cognitive

PO, PA and parental pet care guidance were associated with higher levels of some areas of social cognitive development for example perspective taking abilities, and cognitive flexible problem solving skills (Maruyama, 2011). Furthermore, selfreliance and independent decision skills were higher in pet-owning children compared to children who did not have pets (Poresky \& Hendrix, 1989). However, other areas of cognition were not affected in a similar manner; no differences in attention were found in dog owning children compared to non-dog owners (Gadomski et al., 2015). Caution must be taken when interpreting findings. In addition to their inability to establish causality, most studies inadequately controlled for potential confounding factors. It cannot be concluded pet care guidance increases cognitive function with
respect to higher level thinking and flexible problem solving. These higher cognitive skills may instead be due to good parental guidance in general rather than pet care guidance. Other important confounding factors also need to be ruled out such as the quality of children's home environments, beyond the presence of animals, which has been linked with both the concurrent and longitudinal cognitive development of preschool children (Bradley \& Caldwell, 1984; Poresky, 1996; Poresky \& Hendrix, 1989).

Current research advocates PO and animal interaction as a catalyst for learning and progressing in both cognitive and psychosocial domains (Gee, Church, et al., 2010; Gee, Crist, et al., 2010; Gee, De, et al., 2012; Gee et al., 2007; Gee et al., 2009). The mechanisms behind the influence of pet interaction on cognitive development are not fully understood. Speculations include improved cognitive Executive Functions (EFs) through stress reduction and social support which in turn can positively affect behaviour and academic outcomes (Ling et al., 2016); however, this remains to be tested. Research has suggested that pets may aid a quicker progression of the four major periods of cognitive development (Kidd \& Kidd, 1985) (sensorimotor stage, preoperational stage, stage of concrete operations, and the formal operation stage (Piaget, 1969)); however, further study is warranted. As animals are "predictably unpredictable" (Melson, 2003), pet behaviour to the observing child represents what cognitive development theory (Piaget, 1969) argues is the route of all learning, namely, cognitive incongruity, moderate discrepancy from established schema, and novel information (Endenburg \& van Lith, 2011); however, this statement remains to be tested empirically and it also does not take into account that pet behaviour varies greatly. Younger children (i.e., children in the preoperational stage) may be beginning to learn and develop their concept of social relationships, and interacting with pets may
promote young children's cognitive development; existing research appears to support this idea (Kidd \& Kidd, 1985; Maruyama, 2011). Introducing children to animals during such a sensitive period may produce optimal results in terms of promoting their abilities to enhance social cognitive development (Maruyama, 2011), in particular perspective taking abilities, although more empirical research is needed to infer this. Possible mechanisms may include PO enhancing the progression of the child's internal thinking (i.e., reorganization and advancement) which shapes their schema and may enhance overall cognitive development. In addition, as children include their pets in physical, imaginative, and free play (Kidd \& Kidd, 1985), social and cognitive functioning may be enhanced due to practicing problem solving abilities and creativity (Dansky, 1980). Other than social-cognition, further well-designed research is required on pet ownership that examines mainstream cognitive outcomes such as EF, memory and IQ.

### 3.4.4 Educational

Pets have the potential to improve educational outcomes. For many children, companion animals are likely powerful motivators for learning (Melson, 2003) and development (Melson, 2003; Rud Jr \& Beck, 2003; Svensson, 2014). Pets have also been found to enhance performance in school-related tasks (Svensson, 2014) and enrich children's vocabulary (Poresky \& Hendrix, 1989). Although mechanisms are not clear, this is possibly due to children learning and retaining more about subjects they are emotionally invested in, and furthermore learning is optimized when it occurs within meaningful relationships. Pets also engage children in both verbal and physical reciprocal behaviours (Geerdts et al., 2015). Interestingly, research has demonstrated that pet owners benefit from more advanced biological knowledge than non-pet
owning children suggesting that pets facilitate the development of a more sophisticated, human-inclusive representation of animals, knowledge about the internal structure of animals and factual anatomy (Geerdts et al., 2015; Prokop et al., 2008). So far, no research has investigated the impact of pets on later adolescent educational outcomes. The support of pets in children's learning process is also demonstrated in research involving classroom animals with respect to reading skills (Hall et al., 2016; le Roux et al., 2014), social functioning and academic competence (O'Haire et al., 2013), emotional stability within school and attitudes towards school (Anderson \& Olson, 2006). The evidence base is strongest for dogs; the presence of a dog in the classroom has been shown to help children exercise better cognitive executive functions and perform better academically (Freund, McCune, Esposito, Gee, \& McCardle, 2016). Further research is required to investigate whether PO is associated with academic attainment.

### 3.4.5 Social development

Findings are mixed in terms of the impact of pet ownership on children's social and socio-emotional development. Childhood pet ownership encourages healthy social development in terms of social competence, social networks, social interaction, social communication, empathy and social play behaviour, leading to higher age-adjusted developmental scores (Endenburg \& van Lith, 2011; Güçlü, 2016; Poresky \& Hendrix, 1989). However, it must be noted that pet bonding and, therefore, PA appeared to be a stronger determinant of these benefits than PO (Poresky \& Hendrix, 1989). The finding that pets increase social networks is encouraging; how a child develops is strongly influenced by the child's social network, for example the support provided by social networks can enhance self-esteem and contribute to mental health, by providing
a buffering, protective function against psychosocial stress (Cohen \& Wills, 1985). Research in adults has demonstrated that companion animals can indeed be a catalyst for several dimensions of human social relationships in neighbourhood settings such as incidental social interaction and formation of new friendships (Wood et al., 2015), and this social support can act as a protective factor against social isolation (Wood et al., 2017). In addition, the finding that pets increase social play behaviour and communication is important, and strongly suggests that pets have the potential to encourage the development of effective socially interactive relationships with others. Alternatively, pets might actually be detrimental to social development and may even reduce levels of social interaction with family and friends in some children (Paul \& Serpell, 1996) which is likely due to the child substituting human contact for interaction with their pet. However, the reduced quantity of social interaction does not mean the quality of these human relationships will suffer. In addition, no significant effects were found on the impact of childhood dog ownership on social externalizing outcomes (such as sharing, fighting and understanding others' feelings) (Gadomski et al., 2015), nor social functioning in adolescents (Mathers et al., 2010). Other research finds social provisions in children are enhanced by classroom animals with children displaying more prosocial behaviours with peers (O'Haire et al., 2013). Further highquality research is needed to infer causality. In addition, the majority of the research has been conducted when interactions on social media were not yet very common. Children's experience of "expanded" social networks is very different now than it was a couple of years or decades ago. As more and more children experience friendships (and abuse) online and on social media, the effects of pets on the feelings of social isolation in this context would be particularly cogent.

### 3.4.6 Risks/costs to Children and Adolescents associated with Pet Ownership

Along with the benefits of the ownership of companion animals, which may include improved child behaviour and development, certain negative consequences have been noted. These include zoonotic infections (Robertson, Irwin, Lymbery, \& Thompson, 2000), allergy and asthma (Collin et al., 2015), bites and other injuries (Voith, 2009) and the psychological and emotional costs due to pet bereavement (McNicholas et al., 2005). Young children are at a greater risk of zoonotic infection; this is a particular concern for immunocompromised children (reviewed in (Hemsworth \& Pizer, 2006)). In addition, children are common recipients of animal bites from a household pet (e.g., about 72\%-80\% of children bitten are from a familiar dog (Kahn, Bauche, \& Lamoureux, 2003; Reisner et al., 2011; Schalamon et al., 2006)). Children under 5 years of age are significantly more likely than older children to provoke animals before being bitten and are most at risk of serious injury (Daniels, Ritzi, O'Neil, \& Scherer, 2009; Kahn et al., 2003; Reisner et al., 2011; Reisner, Shofer, \& Nance, 2007).

### 3.4.7 Limitations

The review reveals mixed evidence and conflicting results. In studies investigating PO on human health and development such inconsistent findings are not infrequent due to use of a wide diversity of designs, small effect sizes and small and homogeneous self-selected samples (Barba, 2015; Ioannidis, 2005). In addition the research findings within the field are often limited by lack of replication (Herzog, 2011). Making comparisons between studies presented with some difficulty due to
some papers looked at PO whilst others looked at PA. It is important to recognize that PA may be more important in exerting these potential effects than PO.

This review highlights a number of particular methodological limitations that require addressing in future studies. If these concerns are addressed, then the research quality in the field will be significantly improved. Firstly, there is inconsistency in how studies classify non-pet-owners. The studies reported here did not appear go into any detail regarding comparators; for example youths with recently deceased pets are likely to be regarded as non-pet-owners. Papers commonly specify non-pet owners as "non-dog" and "non-cat" owners; however, this frequently fails to account for potential effects of other companion animals on the outcomes of interest. Pet owners are often treated as one homogenous population without consideration of differences between them or of differences in species owned, their attitudes to PO and PA, both of which are likely to impact potential benefits from their interaction with their pets. Secondly, in some studies, the reliance of subjective self-reported data in place of objective validated outcomes is problematic, due to an increased probability of false negative and false positive reporting.

Thirdly, the majority of studies to date have been cross-sectional, which means that the direction of the association between pet ownership and different aspects of child development cannot be determined. For example, children deemed by their parents as more responsible may be viewed as more ready to take on the role of pet owners, and therefore, more likely to get a pet than children who are viewed as less responsible or mature. This reverse causality could still result in a positive association between pet ownership and responsible behavior, but in this case, responsible behavior would cause pet ownership and not the other way around. Due to the nature of the independent variable (owning a pet or not), research in this field is difficult to be truly
experimental due to ethical considerations, and therefore prospective studies may be more suitable to determine the temporal direction between pet ownership and the outcomes (Endenburg \& van Lith, 2011; Van Houtte \& Jarvis, 1995).

Fourth, longitudinal and prospective studies in PO and child development are needed to determine the long-term consequences for children of establishing relationships with pets and other animals. A lack of longitudinal and epidemiological data in this area hampers the development of appropriate and effective interventions (Barba, 2015).

Fifth, research into the effects of animals on human health and development have also been historically weak in terms of statistical power and the ability to appropriately control for confounding variables (Herzog, 2011). PO has been associated with numerous socio-demographic factors (HSCIC, 2014; Paul \& Serpell, 1992; Westgarth et al., 2010; Westgarth et al., 2012; Westgarth et al., 2007). Conflicting findings may be due, at least in part, to the inadequate control of or adjustment for variables identified as potential confounders. The use of appropriate methodology, including adjustment for confounders, is critical to ensure findings are not over-interpreted, nor any tangible associations missed (Herzog, 2011). Sociodemographic factors may explain postulated psychological and physical health benefits of pets (Downes, Canty, \& More, 2009; Müllersdorf, Granström, Sahlqvist, \& Tillgren, 2010; Murray, Browne, Roberts, Whitmarsh, \& Gruffydd-Jones, 2010; Purewal et al., 2017; Westgarth et al., 2010). Although many studies adjust for at least age and sex of the participants, PO has been associated with other factors (Paul \& Serpell, 1992; Westgarth et al., 2010; Westgarth et al., 2012; Westgarth et al., 2007), such as ethnicity, the number of people in a household, the presence of an older sibling, parental education and social class, maternal age at delivery, maternal pet ownership
history and housing type (Westgarth et al., 2010). The need to control for confounding factors is recognised; studies have identified socio-demographic differences in ownership of different pets types in adults (Downes et al., 2009; Eller et al., 2008; Murray et al., 2010) and children (Westgarth et al., 2013; Westgarth et al., 2010), but less so in adolescents (Marsa-Sambola et al., 2016; Siegel, 1995). Differences between explanatory factors associated with ownership of different types of pets also need to be examined. These factors may differ (Westgarth et al., 2010), but previous research is mostly limited to dog and cat ownership (Downes et al., 2009; Murray et al., 2010; Westgarth et al., 2007).

Furthermore, a child's interaction with pets is mediated by interactions with adults, siblings, and peers. Therefore, a life-course approach is needed to specify mediational models and pathways to later developmental, and to understand the different forms of social and emotional support pets may provide, as well as how this support is contextualized within adult, peer and pet relationships over time (Barba, 2015; Mueller, 2014). For example, a pet may positively influence emotional and mental health of both children and adults within a family unit. Because of the reciprocal nature of all relationships, children who show more positive behavior due to bonding with their pet, may elicit more positive responses from their parents, thus contributing to an overall positive family functioning. In turn, parents, who benefit from lower levels of anxiety or depressive symptoms from owning the same pet, may interact more positively with their children.

Another important limitation for the majority of studies included in the review is that it is not possible to know whether families with children having no or minimal challenges with emotional health or general developmental difficulties are more or less
likely to live with companion animals, compared with families with children having challenges.

Last, it is possible that the published literature on the impact of pets on children's health is biased by selective publication of positive results. For example, studies demonstrating a significant effect of PO may be more likely to be published and cited by others than studies with negative findings. The lack of negative/null findings illustrated in Figure 2 suggests a high likelihood of this "file drawer effect," which may skew the available scientific literature on human-animal relationships (Herzog, 2011).

### 3.5 Conclusions

In summary, current evidence suggests that overall, pet ownership may be beneficial to child and adolescent emotional, cognitive, behavioural, educational and social development. Although the majority of studies performed to date had methodological weaknesses, the pattern of findings among sub-populations and age groups suggests that companion animals have the potential to promote and contribute to healthy child and adolescent development. However, there is a scarcity of research to elucidate the mechanisms through which pet ownership promotes child development. This is required to identify the processes that underlie the observed relationship between PO, PA and child development. Future research should examine the potential effects of different pet types. Although the majority of research has taken into account the types of pets children owned, dogs appear to be the most researched and beneficial, perhaps due to a higher level of interaction and reciprocation in comparison to other pets. There is little understanding so far of potentially differential effects of different types of pets on specific psychological, behavioural, and social
problems (Serpell, Coppinger, Fine, Peralta, \& Aubrey, 2006). Further research is required to investigate the mechanisms through which PO promotes child and adolescent development. Future studies must better account for confounding variables, and preferably use longitudinal and as strictly controlled designs as possible in order to infer causality.

Chapter IV

Methods

This chapter aims to outline the chosen methodology of the project. An introduction to ALSPAC is given; detail on participants, ethical procedures, and an overview on ALSPAC including strengths and limitations of the dataset are presented. The chapter demonstrates why ALSPAC is a valuable resource in addressing the limitations of previous research outlined in chapter 3.

The pet ownership data in ALSPAC are described, including what, when and how data were collected. Previous research has identified the need to control for sociodemographic differences in ownership of different pets types in children (Westgarth et al., 2010). This chapter outlines the aims to extend this research to pet ownership in adolescence in the present study.

An overview of the chosen developmental outcomes in ALSPAC are also given, including an introduction to the developmental outcomes, and information on when and how they have been measured and collected in ALSPAC. Lastly, research hypotheses are given for each developmental outcome.

Lastly, data analysis procedures are explained including statistical analyses for each developmental outcome, the selection of confounding variables according to developmental outcome, and missing data procedures.

The ALSPAC dataset - overview and preparation for analyses

### 4.1 Introduction to ALSPAC

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a UK prospective birth cohort study, originally funded by the World Health Organisation Europe (Boyd et al., 2013). ALSPAC was designed to facilitate research into the understanding of genetic and environmental characteristics influences on health and development in both parents and children (Fraser et al., 2013). ALSPAC sought to enrol pregnant women in the Bristol area of the UK (County of Avon, Southwest England, see figure 6) during 1990-92. Data were collected at multiple time points from pregnancy onwards using postal questionnaires, clinic assessments, biological samples, linkage to routine information, abstraction from medical records and environmental monitoring. Up to the age of 18 years, participants and their families completed 59 questionnaires and nine clinical assessments, as well as over 11,000 children providing DNA samples (Boyd et al., 2013; Fraser et al., 2013). Data from ALSPAC are available and utilised by researchers from a wide range of disciplines, encompassing health, social science and education. Detailed information on the dataset is available at (http://www.bristol.ac.uk/alspac), including a fully searchable datadictionary (http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary). ALSPAC has also been described in further detail elsewhere (Boyd et al., 2013).


Figure 6. ALSPAC eligible study areas

### 4.1.1 Participants

Approximately 14,541 pregnant women were recruited opportunistically through the use of media, routine antenatal and maternity health services, and through recruitment staff visiting community locations. Women with expected delivery dates between $1^{\text {st }}$ April 1991 and $31^{\text {st }}$ December 1992 were recruited. Of the 13,978 singletons/twins alive at one year, a small number of participants withdrew consent (n $=24)$ leaving a starting sample of 13,954 . Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee (ALEC) and the Local Research Ethics Committees (Bristol and Weston Health Authority: E1808 Children of the Nineties: Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) (28th November 1989); Southmead Health Authority: 49/89 Children of the Nineties - "ALSPAC". (5th

April 1990); Frenchay Health Authority: 90/8 Children of the Nineties. (28th June 1990)). Parents provided written informed consent.

### 4.1.2 Strengths of the dataset

ALSPAC data has made a major contribution to research relating to health and development, for example findings that greater maternal prenatal fish consumption is positively associated with verbal IQ and better eyesight (Hibbeln et al., 2007), and that babies are not harmed by sleeping on their backs resulting in the prevention of thousands of cot deaths (Hunt, Fleming, \& Golding, 1997).

The use of ALSPAC data provides numerous strengths, the foremost being its large sample size, the breadth and frequency of data collection and the availability of repeat measures. The dataset used in the present project has been derived from this large sampled well-characterized UK birth cohort, with data collected at multiple time points allowing the assessment of developmental trajectories and critical periods of development. This also allows the consideration of a wide range of confounding variables.

Within ALSPAC, it is possible to examine both current PO and pet ownership history, on developmental outcomes across a number of ages spanning childhood, and adolescence using reliable and valid measurement tools. This is an important advance over previous research.

### 4.1.3 Limitations and biases of the ALSPAC dataset

There are some limitations to using the ALSPAC dataset. Firstly, there are concerns regarding external validity when generalizing ALSPAC findings to the national population. Systematic differences exist between those recruited into ALSPAC, and those not recruited, which may have introduced bias to subsequent estimates based on participants (Boyd et al., 2013). To explore differences, comparisons have been made between those enrolled in the ALSPAC sample and those living anywhere in the UK (Boyd et al., 2013). This demonstrated that children in the ALSPAC enrolled sample have a higher educational attainment at the age of 16 years than the national average (NPD KS4 GME national sample), and this difference is not observed in the ALSPAC eligible sample. Furthermore, the difference becomes more pronounced over time. Children who have not recently participated or are lost to follow-up through study attrition have a lower educational attainment than the national average. There are also other sociodemographic differences; the ALSPAC enrolled sample are more likely to be of a White ethnicity, and less likely to be eligible for free school meals than the NPD KS4 GME national sample. In addition, recent responders are more likely to be female, White and less likely to be eligible for free school meals, whereas those lost to attrition are more likely to be male and eligible for free school meals (Boyd et al., 2013).

The high rates of attrition are another limitation, but are to be expected in longitudinal studies. However, considering that certain participants have been reported as more at risk of selective attrition, particularly ethnic minorities, and those with low family income or low education (Patel, Doku, \& Tennakoon, 2003), it can be argued that ALSPAC attrition rates are lower in comparison to other longitudinal birth cohort
studies, due to mothers of infants in Avon being slightly more likely than those in Britain to live in owner-occupied accommodation and to have a car available to the household, less likely to have one or more persons per room, or be non-White (Boyd et al., 2013). ALSPACs response rates decreased over time, particularly when the study child reached adolescence and young adulthood. Loss to follow-up caused by this attrition reduces the proportion of the sample who are eligible for follow-up at each time point, therefore this reduces power and the availability of repeat measures across multiple time points.

Thirdly, although ALSPAC has collected repeat measures across frequent time points, the early (up to the age of 5 years) collection of data at study assessment clinics was limited to a $10 \%$ subsample (Boyd et al., 2013).

Lastly, ALSPAC did not include a validated measure of 'pet attachment'. Some research suggests that it is our relationship and interaction with our pets which is of more importance than solely PO, if pets are to exert any beneficial health effects on humans (Purewal et al., 2017). In addition, the data we use is slightly tenuous, as children were not asked themselves if they owned pets (maternal/caregiver reported household pet ownership served as a proxy, see chapter 5). Therefore, it could be argued that, in some cases, the child may have interacted little with the pet in reality. The pet ownership measure used therefore may not reflect actual pet interaction in all cases. A pet interaction (PI) variable does exist in ALSPAC however this was asked at one time point only.

### 4.2 Exposure

### 4.2.1 Pet Ownership data

ALSPAC was deemed as appropriate to investigate the aims of the project, as PO data was collected at regular intervals approximately every 18 months.

PO data was reported by the mothers of 13,557 ( $96 \%$ ) children during gestation, and by the caregivers of $7,800(97 \%)$ children by age ten years. It was assumed that the child also lived with any pets reported by the mother/main caregiver. Therefore, caregiver-reported household PO serves as a proxy for the child's interaction with the pet, up to and including age 10. After age 10, household PO was reported by $3,098(52 \%)$ adolescents retrospectively at age 18 years for ages 11-18 years (Figure 6). PO data at age 7 were also collected retrospectively to assess the accuracy of participants' recall during adolescence. The PO data from gestation up to age 10 years has been previously analysed and described in detail (Westgarth et al., 2010). The PO data from 11 years onwards are explored within the thesis (see results chapter 5).

At each age, participants were asked to recall whether they had any pets in their household and if so, how many pets they had of each type. Pet type included cats, dogs, rabbits, rodents (mice, hamster, gerbil, etc.), birds (budgerigar, parrot, etc.), fish, tortoises/turtles, horses and other. Horse ownership was only asked from 10 years onwards. Table 3 shows the time points at which pet ownership data were collected.

Table 3. Time of data collection for PO variables (and sample N for any pet ownership)

| Time of data collection for pet ownership | N (\%) |  |
| :--- | :---: | :---: |
|  | Yes | No |
| Has pets at gestation (8 weeks) | $7846(58)$ | $5711(42)$ |
| Has pets at 8 months | $6054(54)$ | $5208(46)$ |
| Has pets at 21 months | $5797(56)$ | $4568(44)$ |
| Has pets at 33 months (2 years) | $5589(58)$ | $4117(42)$ |
| Has pets at 47 months (3 years) | $5877(61)$ | $3699(39)$ |
| Has pets at 85 months (7 years) | $5972(72)$ | $2359(28)$ |
| Has pets at 97 months (8 years) | $5656(74)$ | $1995(26)$ |
| Has pets at 122 months (10 years) | $5745(74)$ | $2055(26)$ |
| Has pets at 11 years | $2416(79)$ | $647(21)$ |
| Has pets at 13 years | $2333(76)$ | $717(24)$ |
| Has pets at 15 years | $2251(74)$ | $783(26)$ |
| Has pets at 18 years | $2244(72)$ | $854(28)$ |

### 4.2.2 Pet interaction

A variable relating to pet interaction and/or proximity was identified in ALSPAC questionnaires. Parents or caregivers completed a postal questionnaire enquiring about the child's activities when their child was aged 6.4 years (on average). Parents reported if their child looked after a pet at home 'Often', 'Occasionally' or 'Not at all'. The number of children who reported this data is outlined in Table 4.

Table 4. ALSPAC Pet Interaction variable

| $\begin{array}{c}\text { Age } \\ \text { (years) }\end{array}$ | Measure | Variable | N |
| :---: | :---: | ---: | :---: |
| 6 | Parent reported | Child looks after pet at home |  |
|  | questionnaire |  | $\begin{array}{r}\text { Often }\end{array}$ |
|  |  |  | 1342 |
|  |  |  | Occasionally |$) 2946$

### 4.3 Predictors of PO

PO has been associated with numerous socio-demographic factors, which are important to adjust for (see chapter 3). Potential confounding socio-demographic variables within ALSPAC include gender, ethnicity of the child, number of people in household, presence of an older sibling, maternal and paternal education and social class, maternal age at delivery, whether the mother had pets as a child, and house type (See Table 5).

Table 5. Potential predictors or confounders, method and time of data collection, and level of analysis

| Variable | Method and time of data <br> collection | Levels |
| :--- | :--- | :--- |
| Rabnership of a Cat, Dog, Rodent, Bird, Fish, <br> Tortoise/turtles and Horse <br> ownership | Collected retrospectively at 11, <br> 13,15 and 18 years | No, yes |
| Gender | Medical records at birth <br> months questionnaire at 140 | White, mixed, Asian, black, <br> other. <br> Collapsed to 'white' and <br> Ethnicity of child |
| Number of people in household | Derived from mother's <br> questionnaire at 122 months | 3, 4, 5+ <br> Presence of an older sibling <br> Derived from mother's <br> questionnaire (child based) at <br> 18 months |
| Maternal education | Mother's questionnaire at 32 <br> weeks gestation. Highest level <br> indicated | Certificate of Secondary <br> Education (CSE) or no <br> qualification (lowest), <br> vocational, O level, A level, <br> degree (highest) |

$\left.\begin{array}{|l|l|l|}\hline \text { Paternal education } & \begin{array}{l}\text { Mother's questionnaire at 32 } \\ \text { weeks gestation. Highest level } \\ \text { indicated }\end{array} & \begin{array}{l}\text { CSE or no qualification } \\ \text { (lowest), } \\ \text { vocational, O level, A level, } \\ \text { degree (highest) }\end{array} \\ \hline \text { Maternal social class } & \begin{array}{l}\text { Derived from mother's } \\ \text { questionnaire at } 32 \text { weeks } \\ \text { gestation (occupation) }\end{array} & \begin{array}{l}\text { Professional (highest), } \\ \text { Managerial and technical, } \\ \text { Skilled: non-manual, } \\ \text { Skilled: manual, Partly skilled, } \\ \text { Unskilled (lowest) }\end{array} \\ \hline \text { Paternal social class } & \begin{array}{l}\text { Derived from mother's } \\ \text { questionnaire at } 32 \text { weeks } \\ \text { gestation (occupation) }\end{array} & \begin{array}{l}\text { Professional (highest), } \\ \text { Managerial and technical, } \\ \text { Skilled: non-manual, } \\ \text { Skilled: manual, Partly skilled, } \\ \text { Unskilled (lowest) }\end{array} \\ \hline \text { Maternal age at delivery } & \text { Clinical records } & \begin{array}{l}\text { Continuous (years) } \\ \text { OR < 21 years, 21-30 years, } \\ >30 \text { years }\end{array} \\ \hline \text { Mother had pets as a child } & \text { Mother's questionnaire at 33 } & \begin{array}{l}\text { No, not at all; Yes, part of } \\ \text { time; Yes, always }\end{array} \\ \hline \text { House type } & \text { Derived from mother's } \\ \text { questionnaire at } 122 \text { months }\end{array} \quad \begin{array}{l}\text { Detached, semi-detached, end } \\ \text { terrace, terraced, flat/room in } \\ \text { someone else's house/other }\end{array}\right\}$

### 4.3.1 Socio-demographic factors associated with PO amongst Adolescents

It is difficult to determine whether psychological health benefits are due to PO directly, or due to factors linked to both PO and health. The need to control for confounding factors is recognised; studies have identified socio-demographic differences in ownership of different pets types in adults (Downes et al., 2009; Eller et al., 2008; Murray et al., 2010) and children (Westgarth et al., 2013; Westgarth et al., 2010), but less so in adolescents (Marsa-Sambola et al., 2016; Siegel, 1995) (See chapter 3). However, differences between explanatory factors associated with ownership of different types of pets also need to be examined.

Birth cohorts are useful sources of data to examine factors associated with pet ownership, and have been used for this purpose in studies of children (Westgarth et al., 2010). However, differences may exist in the prevalence and frequency of pet ownership among children and adolescents, and there may be differences in the variables that explain PO in childhood and adolescence (Kidd \& Kidd, 1990; Melson, 1988; Westgarth et al., 2013; Westgarth et al., 2010). Furthermore, because youth interaction with pets is mediated by interactions with adults, siblings, and peers, a lifecourse approach is needed to specify mediational models and pathways in human health outcomes over time (Barba, 2015; Mueller, 2014).

The next step was to determine what confounding factors are important to adjust for when thinking about PO and adolescent development.

Previous research has found associations between a wide range of sociodemographic factors and PO in seven-year-old children using ALSPAC data (Westgarth et al., 2010). Variables of importance included gender, presence of older siblings, ethnicity, maternal and paternal education, maternal and paternal social class,
maternal age, number of people in the household, house type, and concurrent ownership of other pets. In the ALSPAC dataset, Westgarth et al. (2010) found that these effects differed depending on the pet type studied. Therefore, the relevant factors to specific pet types must be accounted for in data analysis of PO and improved health outcomes. Whether the mother had pets during her childhood was also a strong predictor of PO in all models, and therefore suggests that mothers of ALSPAC children may have made the choice to own the family pet.

Whether these same or similar socio-economic and demographic factors are of importance in PO during adolescence within the ALSPAC dataset is unknown. This research needs to be extended to adolescence, considering that these factors may not only be important to consider in the current project, but in future Human-Animal Interaction (HAI) research across childhood and adolescence.

One of the aims of this study was to understand PO in adolescence using a large UK birth cohort (the Avon Longitudinal Study of Parents and Children-ALSPAC). Objectives:
5. To compare findings in adolescence to childhood from the same cohort
6. To identify and describe the potential confounding factors associated with ownership of each pet type in adolescence at age 13 years. This age was chosen for examination as it marks the beginning of adolescence and is a period of great change in terms of pubertal, cognitive and socio-emotional development. In addition, this age group was ideal in terms of sample size for each model; pet ownership of smaller pet types was expected to decrease in later adolescence.

### 4.4 Outcomes

This chapter outlines the ALSPAC developmental outcomes chosen for the project. What follows is an introduction to the developmental outcomes chosen, when and how they have been measured in ALSPAC, and why each one is important to investigate.

### 4.4.1 ALSPAC Outcome variables

The developmental outcome variables were derived from a variety of questionnaires completed by mothers/caregivers, or by children themselves collected by post between age 2 and 15 years at specific time points (Table 6), or from questionnaires or tasks conducted in Children in Focus (CiF) research clinics at specific ages. Five broad areas of psychosocial development were chosen for analysis, namely, emotional health, behaviour, cognition, educational and language development.

The literature review (Purewal et al., 2017) (see chapter 3) highlighted that the majority of previous studies looking at the impact of pets on emotional health and behaviour did not use validated outcome measures, and did not look at patterns across time. Therefore, we aimed to address these limitations using the ALSPAC dataset. The developmental outcomes cognition, education and language development were chosen according to gaps in the research (see chapter 3).

Table 6. ALSPAC outcomes and measures selected for the study

| Outcome |  | Age (years) | Measure |
| :---: | :---: | :---: | :---: |
| Emotional <br> Health | Self-esteem | 8 | Harter Self-Perception Profile (HSPP) (CiF clinic) |
|  | Anxiety (separation, social and generalized) | 7, 10 and 13 | Development And Wellbeing Assessment (DAWBA) (child based questionnaire (parent reported)) |
|  | Depression | 7 | DAWBA (child based questionnaire (parent reported)) |
|  |  | 10 and 13 | Mood and Feelings <br> Questionnaire (MFQ) (CiF clinic) |
| Cognition | Selective attention | 8 and 11 | Tests of Everyday Attention for Children (TEACh) (CiF clinic) |
|  | Dividing attention (dual task) |  |  |
|  | Executive function (attentional control/opposite worlds) |  |  |
|  | Inhibition/impulsivity | 10 | Stop-signal task (CiF clinic) |
|  | Working memory | 8 | Digit recall (CiF clinic) |
|  |  | 10 | Counting span task (CiF clinic) |


| Outcome |  | Age (years) | Measure |
| :---: | :---: | :---: | :---: |
| Behaviour | Hyperactivity | 3 and 11 | Revised Rutter Scale (RRS) Strengths and Difficulties Questionnaire (SDQ) (parent reported) |
|  | Emotional symptoms |  |  |
|  | Conduct problems |  |  |
|  | Prosocial behaviour |  |  |
|  | Peer problems | 11 | Strengths and Difficulties Questionnaire (SDQ) (parent reported) |
| Education | KS1 attainment | 7 | SATs |
|  | KS2 attainment | 11 | SATs |
|  | GCSE attainment | 15 | GCSE grades |
| Language | Language development | 2 and 5 | Reynell Development Language Scale (RDLS) (CiF clinic) |
|  |  | 2 | MacArthur Communicative <br> Development Inventories <br> (MCDI) (parent reported) |

### 4.5.1 Emotional Health Outcomes

## Self-esteem

Children aged 8.5 years (on average) completed a shortened version of Harter's Self Perception Profile for Children (SPPC) (Harter, 1985) at a face-to-face CiF clinic. The psychometric properties of the SPPC, including validity and reliability have been established (Herbert \& Iain, 1990). This version consisted of the 12 items from the global self-worth and scholastic competence subscales of the original measure. Scores for the 6 relevant items were summed, with lower scores indicating poorer self-esteem. Low self-esteem in scholastic competence was defined as a score $\leq 14$; low self-esteem in global self-worth as a score $\leq 16$ (Table 16 Chapter 6 ).

## Anxiety

The Development and Well-Being Assessment (DAWBA) (Goodman \& Ford, 2000) was used to measure symptoms of separation anxiety, social anxiety and generalized anxiety disorder at 7,10 (parent-completed) and 13 (child-completed) years, and depression at 7 years (parent-completed). The DAWBA is a validated measure combining structured and semi-structured questions related to the Diagnostic and Statistical Manual of Mental Disorders (DSM) and International Classification of Diseases (ICD) diagnostic criteria. It has been validated for use in child and adolescent epidemiological studies in the UK (Ford, Goodman, \& Meltzer, 2003). Due to the low rate of DSM-IV disorders in ALSPAC, analyses were conducted using a set of dichotomous outcome variables derived from the lists of symptoms in the DAWBA relating to each emotional health outcome. These binary scores were derived as detailed in Table 17 (Chapter 6).

Depressive symptoms at age 10 and 13 years were assessed using the short Mood and Feelings Questionnaire (MFQ) completed by children at Children in Focus (CiF) research clinics (Angold, 1995; Messer, 1995). The MFQ consists of 13 items enquiring about the occurrence of depressive symptoms over the past 2 weeks. The short MFQ is a validated tool widely used in epidemiological studies (Sharp, Goodyer, \& Croudace, 2006). The cut-off point of 11 was used to indicate high levels of depressive symptoms (Table 16, Chapter 6); this cut-off has been shown to have high sensitivity and specificity in children and adolescent populations (Culpin, Heron, Araya, Melotti, \& Joinson, 2013; Thapar \& McGuffin, 1998).

### 4.5.2 Behavioural Outcomes

Revised Rutter Parent Scale for Preschool Children

The Revised Rutter Parent Scale for Preschool Children (RRS) (Rutter, 1970) was administered to parents and caregivers to measure child behaviour at age 3 (42 months). The RRS consists of 43 items measuring the frequency of reported behaviours on a Likert scale. Subscales consisted of four different behavioural aspects; emotional difficulties, conduct difficulties, hyperactivity-inattention difficulties and prosocial behaviour domains (high score indicated more problems). A total behavioural difficulties score was calculated from the sum of the subscales (excluding prosocial behaviour as advised by user manual). Binary scores were derived; as no clinical cut-off score exists for the RRS, cut-offs were calculated using standardized z scores, taking the highest (or lowest) tertile of the RRS subscale. Despite the distinction of internalising and externalising problems being less clear in younger children in comparison to older children, there is some support for concurrent and
predictive validity for subscales of preschool behaviour problems (Sonuga-Barke, Thompson, Stevenson, \& Viney, 1997).

## Strengths and Difficulties Questionnaire

In older children, behavioural problems were assessed using the Strengths and Difficulties Questionnaire (SDQ), which has been validated for use in children aged 4-16 years (Goodman, 1999). The SDQ was completed by the caregiver when the child reached 11 years (140 months). The SDQ behavioural screening scale is similar to the RRS; 25 items were used to score five subscales emotional difficulties, conduct difficulties, hyperactivity-inattention difficulties, prosocial behaviour, and in addition peer relationship difficulties. Likert scales ranged from $0-10$ where higher scores denoted more difficulties. A total behavioural difficulties score was calculated from summing the scores of the subscales (excluding prosocial behaviour). Binary scores were derived using clinical cut off scores for subscales (emotional difficulties=4, conduct difficulties=4, hyperactivity-inattention difficulties=6, prosocial behaviour $=5$, and peer relationship difficulties $=3$, total behavioural difficulties=14).

### 4.5.3 Cognitive Outcomes

Children were invited to, and underwent testing for all cognitive outcomes at CiF clinics at ages 8,10 and 11.

## Attention

The outcome measures for attentional functioning were derived from the Test of Everyday Attention for Children (TEACh) (Manly, Robertson, Anderson, \& Nimmo-Smith, 1998). Selective attention, sustained attention and attentional control were measured.

## 1. Selective Attention (Sky Search Task)

The Sky Search task was completed to assess selective attention at ages 8 and 11 years. In order to demonstrate their ability to focus on a task whilst disregarding distracting stimuli, children were required to circle pairs of identical spaceships from other non-identical spaceships as rapidly as possible. Time and accuracy were recorded. The task was repeated with only identical spaceships to control for motor ability. As recommend in the manual, motor processing reaction time was then subtracted from the ability score to provide a final score of selective attention. A higher score indicates a more impaired selective attention.

## 2. Sustained Attention (Sky Search Dual Task)

The Sky Search Dual task followed the same procedure as the Sky Search task but with the addition of simultaneously presented auditory stimuli. Children were asked to count the auditory stimuli whilst circling spaceships. The final score dual task score was calculated by taking the sky search task's score (prior to adjusting for motor performance), from the score created from the dual task score itself (and so adjusting for the increased decrement in score to the selective attention task when a further task (counting the auditory stimuli) was added). A higher score indicated a more impaired ability in attentional switching.
3. Attentional Control (Same and Opposite World task)

Attentional control was measured at ages 8 and 11 using the Same and Opposite Worlds tasks. Children were shown a string of 24 numbers made up
of either 1 or 2 . In the Same World condition, children were required to verbally read out the numbers in the path. In the Opposite World condition, they were required to inhibit the familiar response by calling out a 'two' when they see the digit 1 , and vice versa. The mean time taken to complete the same world trials was taken as a measure of verbal processing. The mean time on the opposite world trials was taken as the measure of attentional control: higher reaction times indicate more impaired ability.

## Impulsivity/inhibitory control

Impulsivity was measured at age 10 years using the Stop-Signal task at a research clinic. Children were required to select an ' X ' or ' O ' button when they were shown on a computer screen (learned response). When an audible beep (stop signal) occurred on random trials ( 150 or 250 ms before the child's mean reaction time), children were required to make no response resulting in inhibition of the learned response. Performance on this task was measured as number of correct stop signal trials at 150 and 250 ms delay before the mean reaction time.

## Working Memory

The Counting Span Task to assess working memory was completed at age 10. Children were shown a number of red and blue dots on a white computer screen, and were required to count the number of red dots out loud (processing). Children were then asked to recall the number of red dots seen on each screen, in the exact order they were presented (storage). A working memory span score was calculated as the number of correctly recalled sets weighted by the number of screens within each set.

### 4.5.4 Educational Outcomes

SAT (KS1 and KS2)

In childhood, Standardised Assessment Test (SAT) results were used to measure educational attainment. ALSPAC obtained Key Stage 1 (KS1) (Reading, Writing and Mathematics) and Key Stage 2 (KS2) (English, Mathematics and Science) results from Local Education Authorities. In the UK, children sit KS1 SAT examinations at approximately age 7 years, and KS2 SAT examinations at 11 years old. At KS1, the range of levels within which most children will work are 1-3, with a target of 2 which most children reach by the end of the key stage. At KS2, the range of levels within which most children will work are $2-5$, with a target of 4 which most children reach by the end of the key stage.

KS1 scoring

The scale consists of levels 1,2,3 and 4+, with grades A, B and C only within level 2. Level 4+ is assessed by means of Key Stage 2 materials and was combined with level 3 due to few children overachieving. Code W (working towards level 1) means that the child was assessed but did not achieve level 1. Within ALSPAC, KS1 were scored as follows: W (working towards level 1 ) $=0,1=1,2 \mathrm{C}=2,2 \mathrm{~B}=3,2 \mathrm{~A}=$ $4,3 / 4+=5$. KS2 scoring

Total marks achieved in English test: $\mathrm{N}=0-25$ marks, Level $2=26-28$ marks, Level $3=29-48$ marks, Level $4=49-70$ marks, Level $5=71-100$ marks.

Total marks achieved in Maths test: $\mathrm{N}=0-17$ marks, Level $2=18-20$ marks, Level 3 $=21-48$ marks, Level $4=49-77$ marks, Level $5=78-100$ marks.

Total marks achieved in Science test: $\mathrm{N}=0-17$ marks, Level $2=18-20$ marks, Level $3=21-39$ marks, Level $4=40-63$ marks, Level $5=64-80$ marks.

GCSE (KS4)
In adolescence, General Certificate of Secondary Education (GCSE) results were used to measure educational attainment, typically at age 16 years. GCSE is sometimes referred to as Key Stage 4 (KS4). Six outcomes relating to GCSE attainment were used in the analysis: English, Maths, Biological Sciences, Chemistry, Physics, and whether the child achieved five GCSE grades A*-C. GCSE subject scores were derived to examine whether the child achieved optimal grades $\left(A^{*}\right.$ or $A$ compared to B-G). Achieving five or more $\mathrm{A}^{*}-\mathrm{C}$ grades at GCSE was chosen because it is a minimum requirement for many post education training courses or careers, and as such represents an important threshold for young people to exceed (Wright, Kipping, Hickman, Campbell, \& Heron, 2018).

### 4.5.5 Language Development Outcomes

## Reynell Developmental Language Scales

Reynell Developmental Language Scales (RDLS) (Reynell \& Curwen, 1977) (RDLS Comprehension Scale) were used to measure language ability at ages 2 and 5 years in CiF clinics. The RDLS is a standardised assessment of the understanding (comprehension) of spoken language in use in the United Kingdom. The child is asked to respond to and carry out a series of spoken tasks of increasing complexity. At first children were required to select a toy on request either by touching, pointing or eye pointing (e.g. Where is the dog? Where is the chair?); then the child is asked to manipulate the toys to show their understanding (e.g. Put the spoon in the cup; put the brick in the box). The instructions gradually increase in number and complexity of the
concepts involved. The assessment was administered and scored according to the assessment manual (Reynell \& Curwen, 1977).

## Macarthur

An ALSPAC adaptation of the MacArthur Toddler Communication questionnaire (MCDI) (Fenson, Marchman, Thal, \& Dale, 1991) was administered to the mother/caregiver of children aged 2 years. The MCDI allows clinicians to assess early language, non-verbal, and social development in children. A vocabulary, nonverbal communication, social development and total communication score was assessed. A higher sub-score indicates greater communication development.

### 4.6 Research hypotheses according to developmental outcome

Emotional and behavioural health

Given the discrepancies in the literature, the present study uses a large UK birth cohort, the Avon Longitudinal Study of Parents and Children (ALSPAC) to investigate the impact of PO on emotional health (self-esteem, anxiety and depression) and behavioural outcomes (emotional difficulties, hyperactivity, conduct difficulties, peer problems and prosocial behaviour) in childhood and adolescence. I hypothesise that there will be a positive association between PO and positive developmental outcomes. In particular, I predict larger effects for dog ownership than other pets, due to increased social interaction and their potential to increase physical activity, and larger effects amongst younger children and pre-adolescents, who are both more likely to be attached to companion animals (Muldoon, Williams, Lawrence, \& Currie, In Press) and are vulnerable to fluctuations in their emotional health.

Cognition and educational attainment

Given the gaps in the literature, the present study uses ALSPAC to investigate the impact of PO on cognition (attention, impulsivity and memory), and educational attainment (KS1, KS2 and GCSE) in childhood and adolescence. Due to plausible theory relating to how pets can hone and allow the exercise of executive functions, I hypothesise that there will be a positive association between PO and enhanced scores of attention and impulsivity. Due to both the EF literature, along with previous positive findings in the use of classroom animals, it could be hypothesised that there will also be a positive association between PO and better educational outcomes.

## Language development

Lastly, the present study uses ALSPAC to investigate the impact of PO on language development, which has not yet been studied to date. It could be hypothesised that there will be a positive association between PO and children's language development. In particular, I predict there will larger effects for the ownership of dogs, which as the most interactive pets (respond to and obey verbal commands), are more likely to elicit verbal conversation between child and pet.

### 4.7 Confounders

### 4.7.1 Confounding Factors

Considering that the apparent associations between key variables of interest and the effects of owning pets may be influenced by numerous confounding factors, a large range of variables were included within the project dataset. Final confounders in each model were chosen on the basis of previous analyses that have found factors associated with PO in this cohort (Purewal et al., 2019; Westgarth et al., 2010), theoretical plausibility and based on what we know are associated with the predictor and outcome variables from prior research. DAGitty software was used to build causal models for the developmental outcomes (Figures 7-9). Variables remained in the model if there was good evidence for an association ( $\mathrm{P}<0.05$ ) or if removal resulted in substantial change to the effect of other variables ( $10 \%$ or greater).

## Theoretical implications

Sex
Detecting gender differences in PO is difficult to do using only family PO data, as many families have both male and female children (Paul \& Serpell, 1992). Nonetheless, sex of the study child was controlled for within all analyses as there are likely to be differences according to developmental outcome. Few gender differences in PO have been reported in research conducted on children and early adolescents (Siegel, 1995; Westgarth et al., 2013; Westgarth et al., 2010). However girls indicated higher rates of ownership of dogs, cats, rodents, horses, and other pets in middle childhood in other datasets (Westgarth et al., 2013). In the ALSPAC dataset, we see similar results where girls reported higher rates of ownership of rabbits, small mammals, cats (Westgarth et al., 2010) and horses (see Chapter 5).

## Ethnicity

As ALSPAC is not very ethnically diverse, ethnicity is not usually used as a confounder within developmental studies. It was however, controlled for in the language analyses. Previous research has found that compared with non-owners, dog and/or cat owners were more likely to be of Caucasian ethnicity (Miles et al., 2017) and have better English language skills (Miles et al., 2017).

## Maternal emotional health

Maternal mental health is frequently used as a confounding factor in many ASLPAC developmental studies (Barker, Jaffee, Uher, \& Maughan, 2011; Netsi et al., 2018). It can be hypothesised that experiencing poor mental health may impact decisions to own pets, especially in childhood as the parent is the one making the petowning decisions. All models were adjusted for maternal depression (Edinburgh Postnatal Depression Scale EPDS (Cox, Holden, \& Sagovsky, 1987) dichotomized at a cut-off of 13), and maternal anxiety (Crown-Crisp Experiential Index CCI (Birtchnell, Evans, \& Kennard, 1988) dichotomized at a cut-off of 9).

## Socioeconomic Status

Again, it is to be expected that family demographic factors such as socioeconomic status exert some influence on the likelihood of acquisition of pets, as they affect the parent who makes the pet-owning decisions. Socioeconomic status is an important consideration when looking at the pet effect on child development. Previous research has found that compared with non-owners, dog and/or cat owners were significantly less likely to have a child who received free or reduced lunch at school, have higher monthly housing costs, worked more hours per week, and more likely to
live in a house (Miles et al., 2017). Other research has found that dog ownership in the general population decreases as years of education or family affluence level increases (Downes et al., 2009; Eller et al., 2008; Murray et al., 2010). Supporting this, another study found dog ownership in children was associated with higher levels of deprivation (Westgarth et al., 2010). In ALSPAC, throughout childhood and adolescence, professional occupations were least likely to own pets (Westgarth et al., 2010) (see Chapter 5).

Confounding measures of socioeconomic status included highest parental social class (occupational social class 1991 British Office of Population and Census Statistics (OPCS, 1991) classification), maternal education (coded on a five-level scale, with the lowest score indicating lowest educational attainment Certificate of Secondary Education (CSE) or vocational qualification and the highest level indicating university degree), grouped maternal age at delivery ( $<21,21-30$, $>30$ ), overcrowding ( $>5$ people), house type (detached, semi-detached, end-terrace, terraced, flat/room in someone else's house/other), financial difficulties (occurrence of major financial problems since pregnancy versus none), ownership of home (owned accommodation; privately rented; subsidized housing), and housing defects, family income and car access (these variables were mainly derived from questionnaires administered during the antenatal period).

## Family factors

Families who choose to own companion animals may be different to families without companion animals in terms of the 'social climate'. Parenting practices and parental bonding effects on the development of children are difficult to detangle from the contribution made by companion animals (Kotrschal \& Ortbauer, 2003).

Research has found that not only are families with children more likely to have pets (Pet Food Manufacturers Association, 2018), but that PO was found to reach a peak in families with children at middle childhood, between 8 and 12 years (Kidd \& Kidd, 1985) (Melson, 1988) (Paul \& Serpell, 1992), mirroring patterns we see in ALSPAC (see Chapter 5). The number of siblings (Melson, 1988; Paul \& Serpell, 1992; Rost \& Hartmann, 1994), and birth order of children may influence PO (Fifield \& Forsyth, 1999), and the absence of a younger sibling may be an important factor in predicting PO (Westgarth et al., 2010). The degree to which children were attached to their pets was also found to be associated with single or two-parent family environments; children from one-parent families were significantly more attached to their dogs (Bodsworth \& Coleman, 2001). Where appropriate, models were adjusted for older children living with the child, whether the child has a twin, if the child attends day care, and parental marital status (ALSPAC maternally reported questionnaires (Joinson, Sullivan, von Gontard, \& Heron, 2016)) .

## Child factors

Lastly, there are child factors that are important to adjust for when exploring associations between PO and developmental outcomes. These factors are rarely accounted for in previous studies looking at the impact of pets on human development. It is plausible to suggest that children with developmental or temperamental difficulties, and those who have been through stressful live events, may be more likely to own pets, as parents often obtain pets in attempt to relieve their child's difficulties or to hone their social and emotional development (Endenburg \& van Lith, 2011). Where appropriate, models have been adjusted for developmental delay (Denver development scale (Frankenburg \& Dodds, 1967)), child temperament (Toddler

Temperament Scale (Carey \& McDevitt, 1978)), and stressful live events (ALSPAC maternally reported questionnaires (Joinson et al., 2016)).

Other variables of interest

As child involvement in dog walking has been shown to be associated with the strength and type of relationship with the dog (Westgarth et al., 2013), Dog Walking (Number of times in typical week respondent walked or jogged with household $\operatorname{dog}(\mathrm{s})$ ) was used as a substitute confounder for pet attachment; however our findings did not differ (results not shown).

## Causal Models for confounder selection

Legend for figures 7-9

- exposure
(I) outcome
ancestor of exposure and outcome
adjusted variable
- causal path
- biasing path


### 4.7.2 Causal model- Emotional health

Figure 7. Causal model for PO and emotional health outcomes


Analyses were adjusted for sex, maternal depression at ages 6,8 and 11 years and maternal anxiety and ages 6 and 11 years. Measures of family sociodemographic background included: overcrowding, house type at ages 7 and 10 years, and highest parental social class, maternal education, financial difficulties, home ownership status, and car ownership. Other covariates included: developmental delay, IQ (Wechsler Intelligence Scale for Children III, WISC-III (Wechsler, Golombok, \& Rust, 1992)) (accounted for in scholastic competence only), older children living in the house, stressful life events at almost 4 years, 9 and 11 years old and mother-child bonding (maternal enjoyment and confidence scores (Thomson et al., 2014)).

Results did not differ when accounting for parental marital status, child temperament and dog walking (Number of times in typical week respondent walked or jogged with household $\operatorname{dog}(\mathrm{s}))$, therefore these variables were discarded from the final models.

### 4.7.3 Causal model- Cognitive and Educational

Figure 8. Causal model for PO, cognitive and educational outcomes


## Analyses of Cognitive development

Analyses were adjusted for sex, maternal depression at ages 8 and 11 years, and maternal anxiety at ages 6 and 11 years. Measures of family sociodemographic background included: overcrowding at 8 and 10 years, house type at ages 7 and 10 years, and highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership. Other covariates included: birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old and mother-child bonding.

Results did not differ when accounting for parental marital status and financial difficulties therefore these variables were discarded from the final models.

## Analyses of Educational development

Analyses were adjusted for sex, maternal depression at ages 6, 8 and 11 years and maternal anxiety at ages 6 and 11 years. Measures of family sociodemographic background included: overcrowding at 7 and 10 years, house type at ages 7 and 10 years, and highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership. Other covariates included: school identifier, school type, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old and mother-child bonding.

Results did not differ when accounting for parental marital status, maternal smoking, financial difficulties, dog walking, and time spent watching TV, outdoors and doing homework therefore these variables were discarded from the final models.

### 4.7.4 Causal model- Language and Behaviour

Figure 9. Causal model for PO, language and behavioral outcomes


Analyses of Language development

Analyses were adjusted for sex, ethnicity, maternal depression at almost 2 and 4 years and maternal anxiety at ages almost 2 and 4 years. Measures of family sociodemographic background included: overcrowding at 2 years, house type at ages 2 and 3 years, and highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership. Other covariates included: birthweight, child has twin, child attended day care at 15 months, and 4 years, number of languages spoken in the home, developmental delay at 18 months, child temperament, older children living in the house, stressful life events at almost 2 and 4 years old and mother-child bonding.

Results did not differ when accounting for mother or child having seen a speech therapist, or house type therefore these variables were discarded from the final models.

Analyses of Behavioural development

Analyses were adjusted for sex, maternal depression at almost 3 and 11 years, and maternal anxiety at ages almost 3 and 11 years. Measures of family sociodemographic background included: overcrowding at 2 and 10 years, and highest parental social class, maternal education, maternal age at delivery, home ownership status, family income, housing defects and car ownership. Other covariates included: Birthweight, developmental delay at almost 3 years, child temperament at 2 years, older children living in the house, stressful life events at almost 2 and 11 years old and mother-child bonding.

Results did not differ when accounting for house type or dog walking (Number of times in typical week respondent walked or jogged with household $\operatorname{dog}(\mathrm{s})$ ), therefore these variables were discarded from the final model.

### 4.8 Statistical analysis

Data analysis

### 4.8.1 Predictors of PO analyses

Cluster analysis
To enable the comparison of PO history across childhood and adolescence in terms of 'never', 'sometimes' or 'always' owned pets, a two-step cluster method was repeated from the initial paper on childhood PO (Westgarth et al., 2010) using the adolescent data. The two-step cluster method, carried out in SPSS version 24, categorised groups of children in the dataset according to their pet ownership history using a scalable cluster analysis algorithm. Children were organised into groupings using the binary outcome yes/no for each pet type at each time point, resulting in pet ownership history variables for each age which can be used to assess PO patterns over time. For example, for dog ownership, clusters were formed for whether participants always, never or sometimes owned a dog or up to age 11, 13, 15 and 18 years. Because cat and dog ownership was the most frequently reported, using two-step cluster analysis, further clusters were identified at each age for: own dog only; owns cat only; owns both dog and cat; owns neither dog nor cat. With the use of these clusters, it will be possible to separate out the effects of dog and cat ownership in future research.

Multivariable models

Potential risk factors and confounding variables (including concurrent ownership of other pets) were examined for association with ownership of each pet type at the earliest time point available for adolescence, which is 13 years. This was deemed a suitable age to compare to childhood PO at age 7, as it was predicted that
the ownership of certain pet types is likely to decrease in later adolescence. Sociodemographic variables included gender, ethnicity of the child, number of people in household, presence of an older sibling, maternal and paternal education and social class, maternal age at delivery, whether the mother had pets as a child, and house type (See Table 5 in Methods chapter). These variables were chosen to match the potential confounders that were used in the childhood models (Westgarth et al., 2010). The variables were entered into multivariable logistic regressions modelling the selfreported ownership of each specific pet type at child age 13 years. A model was not built for tortoises/turtles due to low frequency of ownership of these pets.

Step-wise backwards elimination, using the likelihood ratio, was used to manually remove variables from each model. Variables remained in the model if there was good evidence for an association ( $\mathrm{P}<0.05$ ) or if removal resulted in substantial change to the effect of other variables ( $10 \%$ or greater). As two-way interaction terms between the variable 'mother owned pets as a child' and other predictor variables were tested at age 7 (Westgarth et al., 2010), this was repeated at age 13, as a reasonable assumption that mother's pet ownership history may continue to influence adolescent PO. The final models were confirmed with stepwise forward addition. The fit of the model was assessed using the Hosmer-Lemeshow statistic.

A large difference in sample sizes between ages 13 and 7, even after multiple imputation, made direct comparison of samples challenging because observed differences could result from sample attrition or non-response, rather than age (nonrespondents in ALSPAC are likely to differ in terms of socio-economic status (Boyd et al., 2013)). Therefore, inferences from imputed models are not presented. In a different approach, a comparison was made by rerunning the age 7 models only for
those participants who had provided data at age 13, effectively using the same sample. These complete case models were compared to the original age 7 models (with the exception of horse ownership as this data was not available at age 7). It is important to note that these predictors of PO may vary due to differences in sample size. Furthermore, a second comparison was made for the 13-year-old models; children excluded from the study due to non-response were compared on key characteristics from those who were included in the final sample at age 13 years (Table 7). The samples appear to differ slightly in terms of gender and parental education (Table 7).

Table 7. Characteristics of the study children at age 13 years in comparison to nonresponders at age 13 years

|  |  | Excluded study children $(n=4,120)$ | Included study children $(n=2,332)$ |
| :---: | :---: | :---: | :---: |
| Variable | Level | Number (\%) | Number (\%) |
| Gender | Male | 2383 (58) | 751 (32) |
|  | Female | 1737 (42) | 1580 (68) |
| Ethnicity | White | 2710 (97) | 1868 (97) |
|  | Non-white | 78 (3) | 50 (3) |
| Number of people in | 3 | 487 (15) | 323 (15) |
| household | 4 | 1525 (48) | 1138 (51) |
|  | 5+ | 1149 (36) | 774 (34) |
| Presence of an older | Yes | 2326 (59) | 1140 (51) |
| sibling at 18 months | No | 1599 (41) | 1095 (49) |
| Maternal education | CSE or no qualification (lowest) | 675 (17) | 222 (10) |
|  | Vocational | 412 (10) | 166 (7) |
|  | O level | 1484 (37) | 722 (32) |
|  | A level | 988 (25) | 647 (29) |
|  | Degree (highest) | 429 (11) | 478 (21) |
| Paternal education | CSE or no qualification (lowest) | 912 (24) | 366 (16) |
|  | Vocational | 372 (10) | 165 (7) |
|  | O level | 907 (24) | 451 (20) |
|  | A level | 1074 (28) | 645 (29) |
|  | Degree (highest) | 584 (15) | 608 (27) |


|  |  | Excluded study children $(n=4,120)$ | Included study children $(\mathrm{n}=2,332)$ |
| :---: | :---: | :---: | :---: |
| Maternal social class | Professional (highest) | 167 (5) | 189 (9) |
|  | Managerial and technical | 1069 (32) | 814 (36) |
|  | Skilled: non-manual | 1490 (44) | 892 (40) |
|  | Skilled: manual | 250 (7) | 131 (6) |
|  | Partly skilled | 313 (9) | 176 (8) |
|  | Unskilled (lowest) | 73 (2) | 33 (2) |
| Paternal social class | Professional (highest) | 350 (10) | 344 (15) |
|  | Managerial and technical | 1202 (33) | 839 (38) |
|  | Skilled: non-manual | 389 (11) | 274 (12) |
|  | Skilled: manual | 1211 (34) | 574 (26) |
|  | Partly skilled | 339 (9) | 167 (8) |
|  | Unskilled (lowest) | 120 (3) | 37 (2) |
| Maternal age at delivery | <21 years | 174 (4) | 56 (3) |
|  | 21-30 years | 2596 (63) | 1292 (58) |
|  | $>30$ years | 1350 (33) | 887 (40) |
| Mother had pets as a child | No, not at all | 256 (7) | 196 (9) |
|  | Yes, part of time | 1574 (43) | 994 (45) |
|  | Yes, always | 1862 (50) | 1045 (47) |
| House type | Detached | 1073 (26) | 764 (34) |
|  | Semi-detached | 1586 (39) | 801 (36) |
|  | End terrace | 403 (10) | 198 (9) |
|  | Terraced | 871 (21) | 396 (18) |
|  | Flat/room in someone else's house/other | 170 (4) | 76 (3) |

### 4.8.2 Developmental outcome analyses

## Emotional and behavioural health

Univariable and multivariable logistic regression analyses were carried out to assess associations between ownership of any pets, dog, cat and other/miscellaneous pets, and the likelihood of having low self-esteem, anxious and depressive symptoms, emotional difficulties, hyperactivity, conduct difficulties, peer problems (age 11), prosocial and total behavioural difficulties. Where significant effects were found for repeated data, the association of PO with anxiety outcomes were assessed using random effects hierarchical regression models in order to account for clustering of data within individuals across all time points in MLwiN version 3.02. The majority of analyses were based on contemporaneous associations of variables, as the data did not allow for lag analyses due to different outcome measures being used at different time points. However, the longer-term impact of PO on emotional and behavioural difficulties was examined by creating and analysing independent variables of differing pet ownership history types created earlier by two-step cluster analyses.

## Cognitive, educational and language development

Univariable and multivariable linear regression analyses were carried out to assess associations amongst ownership of any pets, dog, cat and other/miscellaneous pets, and pet-owning history, with scores of attention, impulsivity and memory, and education (KS1, KS2). Univariable and multivariable linear regression analyses were carried out to assess associations amongst ownership of any pets, dog, cat and other/miscellaneous pets and language development (RDLS total score, and Macarthur total score, vocabulary, non-verbal communication, and social developmental score);
pet ownership history was not investigated due to no suitable pet ownership variable to derive from in ALSPAC. Univariable and multivariable logistic regression analyses were carried out to assess associations between ownership of any pets, dog, cat and other/miscellaneous pets, and pet-owning history, with the likelihood of achieving top GCSE grades (A* or A compared to B-G), and the likelihood of achieving 5 or more GCSE grades $\mathrm{A}^{*}$-C. Where significant effects were found for repeated data, the association of PO with developmental outcomes were assessed using random effects hierarchical linear regression models in order to account for clustering of data within individuals across all time points in MLwiN version 3.02.

## Pet Interaction

The pet interaction (PI) variable was used to examine associations between how often the child looks after the pet and developmental outcomes. As the PI variable was collected at one specific time point (age 6 years), the developmental outcomes that could be explored were: anxiety and depression at age 7 years, and KS1 attainment. All analyses were adjusted for confounding factors used in the original models.

### 4.9 Missing data

Missing data are common in longitudinal studies due to high rates of attrition. The cumulative effect of missing data has the potential to undermine the validity of research results by the exclusion of a substantial proportion of the original sample, which in turn causes a substantial loss of precision and power, and can cause bias by overrepresentation of the sample available for analysis (Spratt et al., 2010) (Sterne et al., 2009). Relatively new statistical techniques for taking account of missing data have been developed, and are being used increasingly. However missing data techniques need to be applied carefully to avoid misleading conclusions. This projects uses two approaches to account for missing data: 1) complete case analyses and 2) multiple imputation.

### 4.9.1 Missing data patterns

In ALSPAC, missing data leads to not just a smaller sample size and loss of information, but also introduces bias. Together, with the demographic profile of the catchment area population and the effects of subsequent attrition have led to an overrepresentation of more affluent groups and an under-representation of non-White minority ethnic groups compared with the national population. Over time, attrition within ALSPAC has also lead to further differences. The samples with complete data differ in terms of socio-economic disadvantage; those lost to follow-up through study attrition had a poorer educational attainment at the age of 16 years than the national average, were more likely to be eligible for free school meals (Boyd et al., 2013) and were also more likely to be male. Table 8 describes missing data patterns for the analyses for the present project.

Table 8. Number (\%) of participants with missing data on each confounding variable.


| Confounder | Original dataset <br> (at gestation, $N=$ <br> 15455) <br> $N$ (\%) | PO data $\begin{gathered} \text { (age } 2, N \\ =9700) \\ N(\%) \end{gathered}$ | PO data <br> (age 3, $N$ $\text { = } 9576 \text { ) }$ <br> $N$ (\%) | PO data $\begin{gathered} \text { (age 7, } N \\ =8325) \\ N(\%) \end{gathered}$ | PO data $\begin{gathered} \text { (age } 8, N \\ =7646) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 10, N \\ =7794) \\ N(\%) \end{gathered}$ | PO data $\begin{gathered} \text { (age } 11, N \\ =3058) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age 13, } N \\ =3044) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 15, N \\ =3034) \\ N(\%) \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Maternal anxiety |  |  |  |  |  |  |  |  |  |
| Age 2 | 5878 (38) | 92 (2) | -- | -- | -- | -- | -- | -- | -- |
| Age 4 | 5878 (38) | -- | 164 (4) | -- | -- | -- | -- | -- | -- |
| Age 6 | 6846 (44) | -- | -- | 721 (9) | 725 (9) | 894 (11) | -- | -- | -- |
| Age 11 | 7805 (51) | -- | -- | -- | -- | -- | 310 (13) | 397 (12) | -- |
| Highest parental social class | 3885 (25) | 444 (8) | 802 (17) | 606 (7) | 504 (7) | 578 (7) | 225 (9) | 296 (10) | 392 (25) |
| Maternal education | 2968 (19) | 165 (3) | 291 (6) | 232 (3) | 196 (3) | 234 (3) | 156 (7) | 195 (6) | 189 (12) |
| Older children | 4325 (28) | 253 (5) | 453 (9) | 264 (3) | 353 (5) | 429 (6) | 213 (9) | 273 (9) | 267 (17) |
| living with child |  |  |  |  |  |  |  |  |  |
| Maternal age at delivery | 1363 (9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 98 | 126 (4) | 122 (8) |


| Confounder | Original dataset (at gestation, $N=$ 15455) <br> $N(\%)$ | $\begin{gathered} \text { PO data } \\ \text { (age } 2, N \\ =9700) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 3, N \\ =9576 \text { ) } \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age 7, } N \\ =8325 \text { ) } \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 8, N \\ =7646) \\ N(\%) \end{gathered}$ | PO data $\begin{gathered} \text { (age } 10, N \\ =7794) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 11, N \\ =3058) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 13, N \\ =3044) \\ N(\%) \end{gathered}$ | PO data (age 15, $N$ $=3034$ ) $N(\%)$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Overcrowding |  |  |  |  |  |  |  |  |  |
| Age 2 | 5301 (34.3) | 489 (9) | -- | -- | -- | -- | -- | -- | -- |
| Age 7 | 7070 (46) | -- | -- | 16 (0) | -- | -- | -- | -- | -- |
| Age 8 | 7782 (50) | -- | -- | -- | 7 (0) | -- | -- | -- | -- |
| Age 10 | 7692 (50) | -- | -- | -- | -- | 61(1) | 360 (14) | 453 (15) | 448 (28) |
| House type |  |  |  |  |  |  |  |  |  |
| Age 2 | 5126 (33) | 715 (15) | -- | -- | -- | -- | -- | -- | -- |
| Age 3 | 5783 (37) | -- | 715 (14) | -- | -- | -- | -- | -- | -- |
| Age 7 | 7069 (46) | -- | -- | 43 (1) | 695 (9) | -- | -- | -- | -- |
| Age 10 | 7329 (48) | -- | -- | -- | -- | 38 (0) | -- | 352 (12) | 286 (22) |
| Financial difficulties | 4126 (27) | 278 (5) | 474 (9) | 376 (5) | 340 (4) | 399 (5) | 202 (8) | 269 (9) | 269 (18) |
| Family income | 6608 (42.8) | 478 (9) | 478 (9) | -- | -- | -- | 438 (18) | -- | 416 (19) |
| Ownership of home | 4212 (27) | 306 (6) | 306 (6) | 419 (5) | 373 (5) | 437 (6) | 209 (9) | 283 (9) | 277 (20) |
| Car access | 4199 (27) | 307 (6) | 307 (6) | 418 (5) | 378 (5) | 440 (6) | 209 (9) | 283 (9) | 276 (18) |


| Confounder | Original dataset <br> (at gestation, $N=$ 15455) <br> $N$ (\%) | PO data $\begin{gathered} \text { (age } 2, N \\ =9700) \\ N(\%) \end{gathered}$ | PO data (age 3, $N$ $=9576$ ) $N(\%)$ | $\begin{gathered} \text { PO data } \\ \text { (age 7, } N \\ =8325 \text { ) } \\ N(\%) \end{gathered}$ | PO data <br> (age $8, N$ <br> $=7646)$ <br> $N$ (\%) | $\begin{gathered} \text { PO data } \\ \text { (age } 10, N \\ =7794) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 11, N \\ =3058) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age 13, } N \\ =3044) \\ N(\%) \end{gathered}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 15, N \\ =3034 \text { ) } \\ N(\%) \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Housing defects | 1731 (11) | 87 (2) | -- | -- | -- | -- | 125 (5) | -- | -- |
| Denver development scale | 5201 (34) | 338 (6) | 338 (6) | 559 (7) | 534 (7) | 638 (8) | 273 (11) | 355 (12) | 351 (23) |
| Child temperament | 5124 (33) | 382 (7) | -- | -- | -- | -- | 250 (10) | -- | -- |
| Stressful life events |  |  |  |  |  |  |  |  |  |
| Age 2 | 5050 (33) | 383 (7) | -- | -- | -- | -- | -- | -- | -- |
| Age 4 | 5855 (38) | -- | 537 (10) | 583 (7) | 577 (8) | -- | -- | -- | -- |
| Age 9 | 7415 (48) | -- | -- | -- | -- | 908 (12) | -- | -- | -- |
| Age 11 | 7792 (51) | -- | -- | -- | -- | -- | 309 | 396 (13) | 391 (25) |
| IQ | 8091 (52) | -- | -- | -- | 1777 (23) | -- | -- | -- | -- |
| School Identifier | -- | -- | -- | -- | -- | -- | -- | -- | 3188 (21) |
| School Type | -- | -- | -- | -- | -- | -- | -- | -- | 3155 (20) |
| Day care |  |  |  |  |  |  |  |  |  |
| Age 1 | 4502 (29) | 512 (9) | 552 (11) | -- | -- | -- | -- | -- | -- |
| Age 4 | 5892 (38) | 652 (12) | 652 (12) | -- | -- | -- | -- | -- | -- |


| Confounder | Original dataset <br> (at gestation, $N=$ | PO data <br> (age 2, $N$ | PO data <br> (age 3, $N$ | PO data (age 7, $N$ | PO data (age $8, N$ | $\begin{aligned} & \text { PO data } \\ & \text { (age } 10, N \end{aligned}$ | $\begin{aligned} & \text { PO data } \\ & \text { (age } 11, N \end{aligned}$ | $\begin{aligned} & \text { PO data } \\ & \text { (age } 13, N \end{aligned}$ | $\begin{gathered} \text { PO data } \\ \text { (age } 15, N \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 15455) | = 9700) | $=9576$ ) | = 8325) | = 7646) | = 7794) | = 3058) | = 3044) | = 3034 ) |
|  | $N(\%)$ | $N(\%)$ | $N(\%)$ | $N(\%)$ | $N(\%)$ | $N(\%)$ | $N(\%)$ | $N(\%)$ | $N(\%)$ |
| Number of | -- | 5314 (34) | -- | -- | -- | -- | -- | -- | -- |
| languages spoken |  |  |  |  |  |  |  |  |  |
| Parenting |  |  |  |  |  |  |  |  |  |
| Maternal | 5876 (38) | 81 (2) | 160 (3) | 771 (9) | 689 (9) | 824 (11) | 295 (12) | 378 (12) | 375 (24) |
| enjoyment |  |  |  |  |  |  |  |  |  |
| Maternal | 5876 (38) | 82 (2) | 162 (4) | 766 (9) | 686 (9) | 822 (11) | 297 (13) | 373 (12) | 370 (24) |
| confidence |  |  |  |  |  |  |  |  |  |
| Maternal bonding | 5955 (39) | 122 (2) | 239 (5) | 589 (7) | 731 (10) | 865 (11) | 308 (13) | 393 (12) | 390 (26) |

### 4.9.2 Missing data mechanism and model

In an attempt to address these biases in incomplete participation, missing data for all confounders in the models (Table 8) were imputed using multiple imputation by chained equations (MICE) (White, Royston, \& Wood, 2011). Predictor and outcome variables were not imputed. The software used for imputation was SPSS version 24. SPSS uses an MCMC (Markov chain Monte Carlo) algorithm known as fully conditional specification or chained equations imputation.

The first stage of imputation is to create multiple copies of the dataset, with the missing values replaced by imputed values. These are sampled from their predictive distribution based on the available observed data (thus using a bayesian approach) (Sterne et al., 2009). For continuous variables, linear regression was used, and for categorical variables logistic regression was used. Five data sets were imputed, as deemed adequate by previous research (Schafer, 1999).

The missing-data mechanism, in line with standard approaches to multiple imputation (Rubin, 1976; Spratt et al., 2010), was plausibly assumed to be Missing at Random (MAR) as opposed to missing completely at random (MCAR) or missing not at random (MNAR). This means the variables included in the imputation model have missing data which is conditional on another variable/s.

Within the thesis, multiple imputation results are presented. Complete case analyses are presented within the appendix for comparison. Where differences exist between imputed data and complete case analyses, attempts are made to understand why (see Discussion Chapter 8). However, as analyses of complete cases suffer more from chance variation; under the missing at random assumption, it is generally accepted that
multiple imputation should correct biases that may arise in complete cases analyses (Sterne et al., 2009).

### 4.10 Interpretation of results

Considering the number of multiple comparisons made within the thesis, reducing the P value criterion (Bonferroni correction) was considered in order to reduce the chance of Type 1 error. However, according to Gelman, Hill, and Yajima (2012) the Bonferroni correction directly targets the Type 1 error problem, but does so at the expense of Type 2 error. Therefore, the Bonferroni correction can severely reduce power to detect an important effect (Gelman et al., 2012).

To remain cautious, this thesis looked at patterns of results, and 'weak' or 'strong' evidence of an association instead of stating statistical significance or relying on the magnitude of P values, in line with ALSPAC recommendations. As advised by Lederer et al. (2019) and , P values were presented but not in isolation; effect estimates are also provided.

## Chapter V

Results: Predictors of Pet Ownership

This chapter aims to explore patterns of pet ownership in the ALSPAC dataset. It presents the results for the predictors of pet ownership, pet ownership trends in ALSPAC and sociodemographic factors in adolescent pet ownership.

## Pet Ownership

The PO data in ALSPAC, from gestation up to age 10 years, has been previously analysed and described in detail (Westgarth et al., 2010).

Statistics on participants reporting the ownership of each pet type at each stage are provided in Figure 10. Example demographics of the sample at age 7 and 13 years, with a reported ownership of any pets, are provided in Table 9.

### 5.1 PO Trends among ALSPAC Participants during Childhood and Adolescence

During gestation, $58 \%$ of ALSPAC mothers reported living in a household with a pet (which we shall term "pet ownership"). Family pet ownership of all types changed across childhood and adolescence (Figure 10). PO data up to 10 years were caregiver-reported. By age 10 years, PO had risen to $74 \%$. Within those numbers, cat ownership was at $31 \%$ and dog ownership was at $26 \%$. There was an increase over time in the frequency of ownership of fish, rodents and rabbits until age 11 years. Thereafter, PO of all pet types other than cats and dogs declined. The largest decrease was in the ownership of small pets (rabbits, fish and rodents) which likely explains the descent in PO as a whole in adolescence. All other pet types stayed fairly constant. By age 18 years, PO stayed reasonably constant at $72 \%$, and dog ownership had risen to $37 \%$. Cats were the most commonly reported pet up to age 15 years; dogs were the most common pet type among older adolescents. This is not consistent with nationwide data, where cat and dog ownership was reported to be equal from 2008-2012 (PFMA, 2016). Overall, these high proportions of ownership allow considerable power to detect statistical differences between pet owners and non-owners.

Figure 10. Ownership of different pet types reported in the ALSPAC cohort from 8 months up to age 18 years. Dotted line indicates 10 years; pet ownership data up to 10 years were caregiver-reported. PO for ages 11-15 years was self-reported by youths at 18 years.


### 5.2 Cluster analysis to examine pet ownership history

Using two-step cluster analysis, clusters emerged from PO up to ages 11, 13, 15 and 18. Including data up to age 11, age 15 and 18 years, only two PO clusters were identified, subsequently termed: "sometimes owned a pet"; and "always owned a pet" (Figure 11). When considering data from all years up to age 13, three PO clusters were identified: "never owned a pet"; "sometimes owned a pet"; and "always owned a pet" (Figure 11).

There is an increased interest in researching dog ownership specifically, perhaps due to a plausibly higher level of interaction and reciprocation in comparison to other pets. Therefore, the clustering process was repeated just for the history of dog ownership. Dog ownership up to 11, 13 and 15 years formed two clusters: "never owned a dog"; and "sometimes owned a dog" (Figure 11). Dog ownership up to 18 years formed 3 clusters: "never owned a dog"; "sometimes owned a dog"; and "always owned a dog" (Figure 11)

Figure 11. Two-step cluster analysis in SPSS to identify ownership length of PO types


Because cat and dog ownership were the most frequently reported, using two-step cluster analysis, further clusters were identified at each age for: "owns dog only"; "owns cat only"; "owns both dog and cat"; "owns neither dog nor cat (Figure 12). Owning both a dog and a cat was fairly low throughout. Interestingly, owning neither dog or cat was decreasing gradually up until 18 years whilst owning either pet seemed to generally increase. At 18 years, a higher distribution owned neither pet type, and a lower distribution owned either a dog or cat.

Figure 12. Two-step cluster analysis in SPSS to segregate reported dog-ownership from cat-ownership

5.3 Characteristics of ALSPAC Families who Reported Owning Pets at Child Age of 13 Years

One aim was to examine whether sociodemographic variables that predict PO at age 7 in this cohort (Westgarth et al., 2010) also predict PO in adolescence at age 13 years. A comparison for the characteristics of the study children with reported PO status at ages 7 and 13 years are described in Table 9. There are some differences between the two time points due to attrition, particularly in gender and maternal education (Table 9).

Table 9. Characteristics of the study children at ages 7 and 13 years who provided pet ownership data

|  |  | Age 7 $(\mathrm{n}=\mathbf{8}, \mathbf{3 3 1})$ | Age 13 $(\mathrm{n}=2,332)$ |
| :---: | :---: | :---: | :---: |
| Variable | Level | Number <br> (\%) | Number (\%) |
| Gender of the child | Male | 4312 (52) | 751 (32) |
|  | Female | 4019 (48) | 1580 (68) |
| Ethnicity of the child | White | 6068 (97) | 1868 (97) |
|  | Non-white | 422(3) | 50 (3) |
| Number of people in | 3 | 1233 (15) | 323 (15) |
| household | 4 | 4168 (50) | 1138 (51) |
|  | 5+ | 2904 (35) | 774 (34) |
| Presence of an older sibling | Yes | 4323 (54) | 1140 (51) |
| at 18 months | No | 3636 (46) | 1095 (49) |
| Maternal education | CSE or no qualification (lowest) | 1631 (21) | 222 (10) |
|  | Vocational | 710 (9) | 166 (7) |
|  | O level | 2873 (35) | 722 (32) |
|  | A level | 2102 (26) | 647 (29) |
|  | Degree (highest) | 1269 (16) | 478 (21) |
| Paternal education | CSE or no qualification (lowest) | 1631 (21) | 366 (16) |
|  | Vocational | 639 (8) | 165 (7) |
|  | O level | 1711 (22) | 451 (20) |
|  | A level | 2199 (28) | 645 (29) |
|  | Degree (highest) | 1683 (21) | 608 (27) |
| Maternal social class | Professional (highest) | 478 (7) | 189 (9) |
|  | Managerial and technical | 2365 (34) | 814 (36) |
|  | Skilled: non-manual | 2957 (43) | 892 (40) |
|  | Skilled: manual | 467 (7) | 131 (6) |
|  | Partly skilled | 550 (8) | 176 (8) |
|  | Unskilled (lowest) | 116 (2) | 33 (2) |


|  |  | Age 7 $(n=8,331)$ | $\begin{aligned} & \hline \text { Age } 13 \\ & (\mathrm{n}=2,332) \end{aligned}$ |
| :---: | :---: | :---: | :---: |
| Variable | Level | Number (\%) | Number (\%) |
| Paternal social class | Professional (highest) | 941 (13) | 344 (15) |
|  | Managerial and technical | 2667 (36) | 839 (38) |
|  | Skilled: non-manual | 858 (12) | 274 (12) |
|  | Skilled: manual | 2154 (29) | 574 (26) |
|  | Partly skilled | 603 (8) | 167 (8) |
|  | Unskilled (lowest) | 189 (3) | 37 (2) |
| Maternal age at delivery | <21 years | 303 (4) | 56 (3) |
|  | 21-30 years | 5043 (61) | 1292 (58) |
|  | >30 years | 2985 (36) | 887 (40) |
| Mother had pets as a child | No, not at all | 743 (10) | 196 (9) |
|  | Yes, part of time | 3517 (46) | 994 (45) |
|  | Yes, always | 3365 (44) | 1045 (47) |
| House type | Detached | 2443 (29) | 764 (34) |
|  | Semi-detached | 3086 (27) | 801 (36) |
|  | End terrace | 771 (9) | 198 (9) |
|  | Terraced | 1652 (20) | 396 (18) |
|  | Flat/room in someone else's house/other | 336 (4) | 76 (3) |

5.4 Multivariable Models of Factors Associated with PO at Age 13 Years

Potential risk factors and confounding variables were examined for association with ownership of each pet type at the earliest time point available for adolescence, which is 13 years, as it was predicted that the ownership of certain pet types is likely to decrease in later adolescence. The results presented in the tables are data derived from multiple imputation and present final multivariable models alongside univariable data for comparison. Findings from complete-case analyses were identical.

## Cat Ownership

Participants were more likely to own a cat (Table 10) if they owned fish, were female and if maternal age at delivery was older (>30 years). Participants with maternal pet ownership history (part of the time, or always) were more likely to own a cat compared to children whose mothers did not own pets during childhood. The Hosmer-Lemeshow statistic was high (0.77), suggesting good model fit.

Table 10. Multivariable binary logistic regression model of cat ownership at 13 years among children who reported any pet ownership.

|  |  | Univariable <br> result <br> (unadjusted) |  |  | Final <br> adjusted <br> model |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Variable | OR | 95\% CI | P | OR | 95\% CI | P |
| Fish |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 1.45 | 1.21-1.73 | $<0.001$ | 1.40 | 1.16-1.69 | <0.001 |
| Gender |  |  |  |  |  |  |
| Male | 1 |  |  | 1 |  |  |
| Female | 1.28 | 1.08-1.49 | 0.003 | 1.29 | 1.09-1.53 | 0.003 |
| Maternal age at delivery |  |  |  |  |  |  |
| <21 yrs | 1 |  | 0.155 | 1 |  | 0.008 |
| 21-30 yrs | 1.31 | 0.78-2.18 | 0.305 | 1.44 | 0.85-2.44 | 0.164 |
| $>30 \mathrm{yrs}$ | 1.47 | 0.88-2.46 | 0.141 | 1.79 | 1.05-3.04 | 0.030 |
| Mother had pets as a child |  |  |  |  |  |  |
| No, not at all | 1 |  | <0.001 | 1 |  | <0.001 |
| Yes, part of the time | 1.55 | 1.08-2.23 | 0.017 | 1.56 | 1.09-2.25 | 0.015 |
| Yes, always | 3.08 | 2.19-4.30 | <0.001 | 3.10 | 2.21-4.37 | <0.001 |

Hosmer-Lemeshow statistic $=0.77, \mathrm{n}=2923$. Analyses were adjusted for: fish ownership, gender, maternal age at delivery and mother had pets as a child.

## Dog Ownership

Participants were more likely to own a dog (Table 11) if they also owned a bird, fish or horse, or had an older sibling. The older the mother was at delivery, the less likely the child was to report living with a dog. The Hosmer-Lemeshow statistic was high (0.83), suggesting good model fit.

Table 11. Multivariable binary logistic regression model of dog ownership at 13 years.

|  |  | Univariable <br> result <br> (unadjusted) |  |  | Final adjusted model |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Variable | OR | 95\% CI | P | OR | 95\% CI | P |
| Bird |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 2.53 | 1.81-3.52 | <0.001 | 2.12 | 1.47-3.03 | <0.001 |
| Fish |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 1.43 | 1.19-1.71 | $<0.001$ | 1.29 | 1.06-1.57 | 0.009 |
| Horse |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 10.32 | 6.43-16.55 | $<0.001$ | 10.43 | 6.34-17.18 | <0.001 |
| Older sibling at 18 months |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 1.36 | 1.15-1.59 | $<0.001$ | 1.50 | 1.26-1.79 | <0.001 |
| Maternal age at delivery |  |  |  |  |  |  |
| $<21$ yrs | 1 |  | $<0.001$ | 1 |  | <0.001 |
| 21-30 yrs | 0.46 | 0.29-0.73 | 0.001 | 0.44 | 0.27-0.72 | <0.001 |
| >30 yrs | 0.36 | 0.23-0.58 | $<0.001$ | 0.32 | 0.20-0.53 | $<0.001$ |

Hosmer-Lemeshow statistic $=0.83, \mathrm{n}=2922$ Analyses were adjusted for: bird, fish and horse ownership, whether the child has an older sibling and maternal age at delivery.

## Rabbit Ownership

The Hosmer-Lemeshow statistic for the rabbit model (Table 12) was low (0.22), suggesting a poor model fit. Therefore, results should be interpreted with caution. This could be due to additional unknown confounding. Participants were more likely to report owning a rabbit if they also owned a rodent, fish, horse, were female, or if the mother owned pets as a child. Those with maternal education at degree level were less likely to own a rabbit.

Table 12. Multivariable binary logistic regression model of rabbit ownership at 13 years.

|  |  | Univariable result (unadjusted) |  |  | Final adjusted model |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Variable | OR | 95\% CI | P | OR | 95\% CI | P |
| Rodent |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 2.23 | 1.80-2.77 | <0.001 | 1.98 | 1.58-2.48 | <0.001 |
| Fish |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 1.82 | 1.46-2.28 | <0.001 | 1.60 | 1.26-2.02 | <0.001 |
| Horse |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 2.20 | 1.43-3.39 | <0.001 | 1.92 | 1.22-3.01 | 0.005 |
| Gender |  |  |  |  |  |  |
| Male | 1 |  |  | 1 |  |  |
| Female | 1.69 | 1.35-2.12 | $<0.001$ | 1.53 | 1.21-1.94 | $<0.001$ |
| Maternal Education |  |  |  |  |  |  |
| CSE/None | 1 |  | 0.002 | 1 |  | 0.014 |
| Vocational | 0.59 | 0.35-1.04 | 0.052 | 0.61 | 0.35-1.04 | 0.68 |
| O Level | 0.90 | 0.64-1.28 | 0.582 | 0.94 | 0.66-1.35 | 0.750 |
| A Level | 0.86 | 0.60-1.23 | 0.393 | 0.89 | 0.62-1.28 | 0.544 |
| Degree | 0.53 | 0.35-0.78 | 0.001 | 0.56 | 0.37-0.84 | 0.005 |
| Mother had pets as a child |  |  |  |  |  |  |
| No, not at all | 1 |  | 0.004 | 1 |  | 0.023 |
| Yes, part of the time | 1.71 | 1.10-2.64 | 0.016 | 1.70 | 1.09-2.64 | 0.019 |
| Yes, always | 1.96 | 1.27-3.03 | 0.002 | 1.70 | $\begin{aligned} & 1.109- \\ & 2.64 \end{aligned}$ | 0.018 |

Hosmer-Lemeshow statistic $=0.22, n=2656$. Analyses were adjusted for rodent, fish and horse ownership, gender, maternal education and mother had pets as a child.

## Rodent Ownership

Participants were more likely to report owning a rodent (Table 13) if they: owned a rabbit, fish, were female, had higher numbers of people living in the household, or their mother sometimes owned pets as a child. Participants were less likely to report owning a rodent if they had older siblings and a higher maternal education. The Hosmer-Lemeshow statistic was high (0.92), suggesting good model fit.

Table 13. Multivariable binary logistic regression model of rodent ownership at 13 years.

|  |  | Univariable <br> result <br> (unadjusted) |  |  | Final adjusted model |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Variable | OR | 95\% CI | P | OR | 95\% CI | P |
| Rabbit |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 2.23 | 1.80-2.77 | $<0.001$ | 1.78 | 1.39-2.31 | <0.001 |
| Fish |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 1.92 | 1.58-2.32 | <0.001 | 1.94 | 1.56-2.42 | <0.001 |
| Gender |  |  |  |  |  |  |
| Male | 1 |  |  | 1 |  |  |
| Female | 2.01 | 1.66-2.43 | $<0.001$ | 2.12 | 1.79-2.63 | <0.001 |
| Number of people in household |  |  |  |  |  |  |
| 3 | 1 |  | 0.005 | 1 |  | 0.018 |
| 4 | 1.37 | 1.04-1.83 | 0.028 | 1.42 | 1.04-1.95 | 0.027 |
| 5+ | 1.65 | 1.22-2.26 | 0.002 | 1.62 | 1.16-2.26 | 0.005 |
| Older sibling at 18 months |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 0.912 | 0.76-1.09 | 0.305 | 0.75 | 0.66-0.97 | 0.005 |
| Maternal education |  |  |  |  |  |  |
| CSE/None | 1 |  | 0.29 | 1 |  | 0.037 |
| Vocational | 0.70 | 0.46-1.08 | 0.113 | 0.57 | 0.46-1.13 | 0.035 |
| O Level | 0.75 | 0.55-1.01 | 0.056 | 0.59 | 0.56-1.05 | 0.004 |
| A Level | 0.85 | 0.63-1.16 | 0.312 | 0.71 | 0.66-1.26 | 0.56 |
| Degree | 0.87 | 0.43-1.19 | 0.403 | 0.77 | 0.73-1.41 | 0.163 |
| Mother pets as a child |  |  |  |  |  |  |
| No, not at all | 1 |  | 0.001 | 1 |  | 0.029 |
| Yes, part of time | 1.04 | 0.76-1.44 | 0.792 | 1.03 | 0.73-1.44 | 0.013 |
| Yes, always | 1.44 | 1.04-2.01 | 0.030 | 1.37 | 0.97-1.94 | 0.742 |

Hosmer-Lemeshow statistic $=0.92, \mathrm{n}=2863$. Analyses were adjusted for: rabbit and fish ownership, gender, overcrowding, whether the child had an older sibling, maternal education and mother had pets as a child.

## Bird Ownership

Participants were more likely to have a bird (Table 14) if they also owned a fish or horse. Likelihood of owning a bird decreased with increasing maternal education level, and was highest in skilled manual, and part-skilled paternal occupations. The Hosmer-Lemeshow statistic was adequate (0.57), suggesting good model fit.

Table 14. Multivariable binary logistic regression model of bird ownership at 13 years.

|  |  | Univariable result (unadjusted) |  |  | Final adjusted model |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Variable | OR | 95\% CI | P | OR | 95\% CI | P |
| Fish |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 2.34 | 1.66-3.30 | <0.001 | 2.29 | 1.60-3.28 | <0.001 |
| Horse |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 3.79 | 2.19-6.54 | <0.001 | 3.68 | 2.07-6.53 | <0.001 |
| Maternal education |  |  |  |  |  |  |
| CSE/None | 1 |  | <0.001 | 1 |  | 0.006 |
| Vocational | 0.41 | 0.18-0.92 | 0.031 | 0.39 | 0.16-0.90 | 0.028 |
| O Level | 0.50 | 0.31-0.81 | 0.005 | 0.54 | 0.32-0.86 | 0.016 |
| A Level | 0.48 | 0.29-0.80 | 0.005 | 0.632 | 0.37-1.07 | 0.09 |
| Degree | 0.17 | 0.08-0.35 | <0.001 | 0.26 | 0.12-0.55 | 0.001 |
| Paternal Social Class |  |  |  |  |  |  |
| Professional | 1 |  | <0.001 | 1 |  | 0.003 |
| Managerial and technical | 1.16 | 0.58-2.29 | 0.674 | 0.96 | 0.48-1.94 | 0.899 |
| skilled non-manual | 1.12 | 0.49-2.57 | 0.785 | 0.86 | 0.37-1.99 | 0.730 |
| skilled manual | 2.65 | 1.42-4.94 | 0.002 | 1.92 | 1.01-4.03 | 0.060 |
| part skilled | 3.92 | 1.91-8.07 | $<0.001$ | 2.72 | 1.23-5.87 | 0.010 |
| unskilled | 2.45 | 0.57-10.54 | 0.222 | 1.40 | 0.31-5.64 | 0.66 |

Hosmer-Lemeshow statistic $=0.57 \mathrm{n}=2922$. Analyses were adjusted for fish and horse ownership, maternal education and paternal social class.

## Fish Ownership

Model is not presented as according to the Hosmer-Lemeshow statistic (0.0015), it was not a good fit for the data.

## Horse Ownership

Participants were more likely to own a horse (Table 15) if they owned a dog, rabbit, or were female. Participants living in a semi-detached and terraced house were less likely to own a horse (in comparison to living in a detached house). The HosmerLemeshow statistic was very high, (0.92) suggesting good model fit.

Table 15. Multivariable binary logistic regression model of horse ownership at 13 years.

|  |  | Univariable <br> result <br> (unadjusted) |  |  | Final <br> adjusted <br> model |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Variable | OR | $\mathbf{9 5 \%} \mathbf{C I}$ | $\mathbf{P}$ | $\mathbf{O R}$ | $\mathbf{9 5 \%} \mathbf{C I}$ | $\mathbf{P}$ |
| Dog |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 10.32 | $6.43-16.55$ | $<0.001$ | 10.43 | $6.36-17.10$ | $<0.001$ |
| Nabbit |  |  |  |  |  |  |
| Yes | 1 | 2.20 | $1.43-3.39$ | $<0.001$ | 1.37 | $0.79-2.37$ |
| Male | 1 |  |  |  | 0.006 |  |
| Female | 3.01 | $1.81-.5 .02$ | $<0.001$ | 3.15 | $1.82-5.45$ | $<0.001$ |
| Gender |  |  |  |  |  |  |
| House Type |  |  | 0.002 | 1 |  |  |
| Detached | 1 |  | 0.019 | 0.57 | $0.35-0.94$ | 0.027 |
| Semi-detached | 0.57 | $0.36-0.91$ | 0.214 | 0.62 | $0.28-1.35$ | 0.235 |
| End terrace | 0.62 | $0.29-1.32$ | 0.004 |  |  |  |
| Terraced | 0.32 | $0.15-0.66$ | .002 | 0.33 | $0.15-0.69$ | 0.003 |

Hosmer-Lemeshow statistic $=0.92 \mathrm{n}=2866$. Analyses were adjusted for dog and rabbit ownership, gender and house type.

## Summary

Not all of the predictors identified at 7 years of age were statistically significant at 13 years (with the exception of gender and concurrent pet ownership), although generally speaking, when examining ORs and $95 \%$ CIs, trends pointed in the same direction.

## Chapter VI

Results: Emotional and Behavioural Health

This chapter aims to explore the association between pet ownership and emotional and behavioural health difficulties. It presents the emotional health (self-esteem, anxiety and depression), and behavioural development results (emotional difficulties, hyperactivity, conduct disorder, prosocial difficulties). It finds little evidence of an association between pet ownership and emotional health, but some evidence between pet ownership and behavioural development outcomes. Imputed data are presented. Results were consistent between complete-case and imputed datasets (see appendices).

### 6.1 Emotional Health

Figure 13. Flow chart depicting sample sizes and derivation for self-esteem at age eight


Figure 14. Flow chart depicting sample sizes and derivation for separation anxiety


Figure 15. Flow chart depicting sample sizes and derivation for social anxiety


Figure 16. Flow chart depicting sample sizes and derivation for generalised anxiety disorder


Figure 17. Flow chart depicting sample sizes and derivation for depression


Prevalence of child emotional health symptoms in the study population are presented in Tables 16 and 17. 20-24\% of the sample met the criteria for low selfesteem (Table 14). For separation anxiety, $7 \%$ met the cut-off score at age $7,6 \%$ met the cut-off score for age 10 and $4 \%$ at age 13 (Table 17). For social anxiety, $6 \%$ met the cut-off score at ages 7 and 10, and $8 \%$ met the cut-off score at age 13 (Table 17). For generalized anxiety $9 \%$ met the cut-off at age 7, 20\% at age 10, and $18 \%$ at age 13 (Table 17). For depression, $12 \%$ met the cut-off score at age 7 (Table 17), $4 \%$ met the cut-off score at age 10 , and $9 \%$ met the cut of score at age 13 (Table 16).

As expected, the prevalence of mood disorders and social anxiety increased, but separation anxiety decreased from age 7 to age 13 years. Similar prevalence rates have been found in the UK for any emotional disorder in 5-10 year-olds (4\%) and in 11 to 16 year-olds (9\%) (NHS Digital, 2018), however slightly higher prevalence rates for mental disorders ( $10-20 \%$ ) have been reported internationally for children and adolescents (World Health Organization, 2019).

Table 16. Prevalence of child emotional health symptoms in the study population

| Age | Measure | $N(\%)$ |
| :---: | :---: | :---: |
| 8 | Harter's Self Perception Profile for Children Low scholastic competence | $\begin{aligned} & 998(23.9) \text { (score range }=6-24 ; \leq 14=\text { low } \\ & \text { score) } \end{aligned}$ |
| 8 | Harter's Self Perception Profile for Children Low global self-worth | $\begin{aligned} & 807(20.3) \text { (score range }=6-24 ; \leq 16=\text { low } \\ & \text { score) } \end{aligned}$ |
| 10 | Moods and Feelings Questionnaire | 327 (4.4) (>11 indicates high levels of depressive symptoms) |
| 13 | Moods and Feelings <br> Questionnaire | 551 (9.2) (>11 indicates high levels of depressive symptoms) |

Table 17. Prevalence in the Study Population of Symptom-Based Outcome Variables (and a description of how they were derived from the DAWBA)

| Age | Outcome <br> Variables Derived From <br> DAWBA | Prevalence in <br> ALSPAC <br> Study <br> Population, $N$ (\%) | Derivation of Dichotomous Outcome Variables From List of Symptoms in DAWBA and Examples of Items in DAWBA Relating to Each Outcome |
| :---: | :---: | :---: | :---: |
| 7 | Separation anxiety | 542 (7.2) | Any separation anxiety symptom(s) "a lot more than others" compared with "no |
| 10 |  | 482 (6.6) | more than others" or "a little more than |
| 13 |  | 259 (4) | others," for example, has he/she worried about sleeping alone? |
| 7 | Social fears | 438 (5.5) | Any social fears "a lot" compared with |
| 10 |  | 479 (6.2) | "none," "a little," or "hasn't done this in |
| 13 |  | 581 (8.2) | the last month," for example, has he/she been afraid of meeting new people? |
| 7 | Generalized anxiety | 687 (8.5) | Any of the worries "often" compared with "sometimes" or "not at all," for example, |
| 10 |  | 671 (20.3) | does he/she worry a lot about schoolwork, |
| 13 |  | 510 (18) | homework, or tests/examinations? |
| 7 | Low mood/ depression | 955 (11.9) | Any mood symptoms compared with none, for example, did he/she think about death a lot? |

### 6.1.1 Self-esteem

There was evidence of an association between owning pets (in particular, dogs and cats) and lower odds of high self-esteem regarding scholastic competence at age 8 (Table 18). In the adjusted model, the association with dog ownership was attenuated to no evidence, but the association with owning 'any pet' and cat ownership remained. There was good evidence of an association between owning any pets (OR $0.85,95 \%$ CI 0.73-0.98; $p=\cdot 026$ ) or cats (OR $0.83,95 \%$ CI $0.73-0.95 ; p=\cdot 006$ ) and lower selfesteem (scholastic competence) demonstrating a lower likelihood of having high selfesteem in pet or cat owners.

In contrast, there was no evidence of an association between PO and global self-worth at age 8 (Table 18).

Table 18. Univariable and multivariable associations between pet ownership at age 8 and the likelihood of low self-esteem, as measured with the Harter Self-perception profile subscales (scholastic competence and global self-worth) at age 8.

*P<. 05

Analyses adjusted for: sex, maternal depression measured at child age 8 , maternal anxiety measured at child age 6 , overcrowding (child age 8 ), house type (child age 7), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, car ownership, older children living with child, developmental delay measured at child age 30 months old, IQ measured at child age 8 years (accounted for in scholastic competence only), stressful life events measured at child age 4 years and maternal bonding measured at child age 3 .

### 6.1.2 Anxiety

At ages 7, 10 and 13, there was no association between PO and the likelihood of separation anxiety, either before or after adjusting the models for potential confounders (Table 19).

At age 7, there was evidence of an association between owning any pets ( $O R$ $1.31,95 \%$ CI 1.03-1.67; $p=\cdot 027$ ) or owning 'other/miscellaneous' pets (OR $1.28,95 \%$ CI 1.04-1.57; $p=\cdot 021$ ) and higher odds of social anxiety, that remained after adjustment for confounders. The association between owning any pets and social anxiety did not remain after accounting for scores at all three time points within a repeated measures model $(\mathrm{OR}=0.09,95 \% ~ C I-0.29-0.49, \mathrm{p}=.621)($ Table 20 $)$.

On univariable analysis, there was evidence of an association between cat ownership at age 10 and higher odds of experiencing generalized anxiety (Table 19). However after the model was adjusted for potential confounding factors, the association disappeared.

Table 19. Univariable and multivariable associations between pet ownership at ages 7,10 and 13 and the likelihood of separation anxiety, social anxiety, and generalized anxiety disorder symptoms at ages 7, 10 and 13 years.




|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Age |  |  |  |  |  |  |
| Generalized Anxiety |  |  |  |  |  |  |
| Has Dog |  |  |  |  |  |  |
| 7 |  | 7240 | 0.98 (0.80, 1.20) | 0.872 | 0.98 (0.79, 1.20) | 0.828 |
| 10 |  | 2889 | 1.19 (0.97, 1.47) | $0.089$ | 1.17 (0.95, 1.46) | 0.145 |
| 13 |  | $1129$ | 1.10 (0.79, 1.53) | $0.547$ | 0.98 (0.69, 1.38) | $0.891$ |
| Has Cat |  |  |  |  |  |  |
| 7 |  | 7239 | 1.19 (0.99, 1.41) | 0.055 | 1.12 (0.94, 1.34) | 0.205 |
| 10 |  | 2889 | 1.25 (1.03, 1.51) | 0.022* | 1.19 (0.99, 1.46) | $0.068$ |
| 13 |  | 1130 | 1.14 (0.83, 1.55) | 0.419 | 1.08 (0.78, 1.50) | 0.647 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 7 |  | 7240 | 1.07 (0.91, 1.27) | 0.379 | 1.11 (0.94, 1.32) | 0.215 |
| 10 |  | 2889 | 1.05 (0.87, 1.26) | 0.632 | 1.02 (0.85, 1.24) | 0.803 |
| 13 |  | 1128 | 1.05 (0.78, 1.42) | 0.735 | 1.02 (0.75, 1.40) | 0.890 |

Analyses adjusted for: sex, maternal depression measured at child age 8 and 11 years, maternal anxiety measured at child age 6 and 11 years, overcrowding (child age 7, 8 and 10 years), house type (child age 7 and 10 years), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at child age 3, 9 and 11 years and maternal bonding measured at child age 3 years

Table 20. Univariable and multivariable random effects hierarchical model for 'Any' pet ownership and Social Anxiety

|  | Unadjusted <br> estimate | Unadjusted CI | $P$ | Adjusted <br> estimate | Adjusted CI |
| :--- | :--- | :--- | :--- | :--- | :--- |

Analyses adjusted for: sex, maternal depression measured at child age 8 and 11 years, maternal anxiety measured at child age 6 and 11 years, overcrowding (child age 7,8 and 10 years), house type (child age 7 and 10 years), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at child age 3, 9 and 11 years and maternal bonding measured at child age 3 years

### 6.1.3 Depression

There was no evidence of an association between PO and the likelihood of depression at ages 7, 10 and 13 years (Table 21).

Table 21. Univariable and multivariable associations between pet ownership at ages 7, 10 and 13 years and the likelihood of depression at ages 7, 10 and 13 years

|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Age |  |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |  |
| 7 |  | 7194 | 1.07 (0.91, 1.26) | 0.391 | 1.08 (0.91, 1.27) | 0.384 |
| 10 |  | 6054 | 0.96 (0.72, 1.18) | 0.789 | 0.94 (0.70, 1.26) | 0.666 |
| 13 |  | 2332 | 1.30 (0.92, 1.84) | 0.126 | 1.03 (0.72, 1.48) | 0.856 |
| Has Dog |  |  |  |  |  |  |
| 7 |  | 7192 | 1.07 (0.90, 1.27) | 0.406 | 1.09 (0.91, 1.29) | 0.349 |
| 10 |  | $6053$ | 0.98 (0.73, 1.32) | 0.932 | 0.96 (0.71, 1.29) | 0.776 |
| 13 |  | 2337 | 1.12 (0.83, 1.51) | 0.447 | $0.94(0.69,1.29)$ | 0.695 |
| Has Cat |  |  |  |  |  |  |
| 7 |  | 7191 | 1.12 (0.96, 1.31) | 0.129 | 1.05 (0.90, 1.23) | 0.504 |
| 10 |  | 6053 | 1.02 (0.78, 1.34) | 0.868 | 0.93 (0.71, 1.23) | 0.617 |
| 13 |  | 2338 | 1.16 (0.87, 1.55) | 0.302 | 0.98 (0.73, 1.32) | 0.895 |


|  | Univariable |  |  |  |  | Multivariable |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age | $N$ | OR $(95 \% \mathrm{CI})$ | $p$ | OR (95\% CI) | $p$ |  |  |
| $\mathbf{7}$ | Has other/miscellaneous pets |  |  |  |  |  |  |
| $\mathbf{1 0}$ |  | 7192 | $1.03(0.89,1.18)$ | 0.673 | $1.07(0.92,1.24)$ | 0.384 |  |
| $\mathbf{1 3}$ |  | 6053 | $1.84(0.84,1.39)$ | 0.532 | $1.10(0.86,1.43)$ | 0.449 |  |
| *P $<.05$ | 2336 | $1.08(0.82,1.42)$ | 0.572 | $0.97(0.73,1.29)$ | 0.828 |  |  |

Analyses adjusted for: sex, maternal depression measured at child age 8 and 11 years, maternal anxiety measured at child age 6 and 11 years, overcrowding (child age 7, 8 and 10 years), house type (child age 7 and 10 years), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at child age 3, 9 and 11 years and maternal bonding measured at child age 3 years

### 6.1.4 Pet Ownership history

There was no evidence of an association between the pet history clustering variable (Always, Sometimes, and Never owned pets up to 13 years) and anxious and depressive symptoms at 13 years (Table 22).

Table 22. Univariable and multivariable associations between pet ownership history (always, sometimes, and never owned pets up to 13 years) and the likelihood of anxiety and depression at 13 years.

|  | Univariable |  |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Pet Ownership | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| history |  |  |  |  |  |
| Separation Anxiety |  |  |  |  |  |
| Never | 1783 | 1 |  | 1 |  |
| Sometimes |  | 1.55 (0.68, 3.54) | 0.298 | 0.82 (0.52, 1.30 | 0.399 |
| Always |  | 1.61 (0.74, 3.49) | 0.234 | 0.90 (0.59, 1.38) | 0.634 |
| Social Anxiety |  |  |  |  |  |
| Never | 1936 | 1 |  | 1 |  |
| Sometimes |  | 0.93 (0.59, 1.46) | 0.761 | 0.82 (0,52, 1.30) | 0.399 |
| Always |  | 1.01 (0.67, 1.52) | 0.981 | 0.90 (0.59, 1.38) | 0.634 |
| Generalized Anxiety Disorder |  |  |  |  |  |
| Never | 849 | 1 |  | 1 |  |
| Sometimes |  | 1.31 (0.83, 2.07) | 0.250 | 1.17 (0.72, 1.89) | 0.529 |
| Always |  | 0.99 (0.63, 1.55) | 0.963 | 0.89 (0.55, 1.42) | 0.610 |


|  | Univariable |  |  |  | Multivariable |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Pet Ownership |  | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) |
| history |  |  | $p$ |  |  |
|  | Depression | 1706 | 1 |  |  |
| Never |  | $0.93(0.59,1.46)$ | 0.765 | $0.75(0.47,1.19)$ | 0.220 |
| Sometimes |  | $1.09(0.73,1.63)$ | 0.677 | $0.84(0.55,1.29)$ | 0.425 |
| Always |  |  |  |  |  |

Analyses adjusted for: sex, maternal depression measured at child age 11 years, maternal anxiety measured at 11 years, overcrowding (10 years), house type ( 10 years), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at 11 years and maternal bonding measured at child age 3 years.

## Pet Interaction

There was no evidence of an association between PI and the likelihood of emotional health difficulties before and after adjusting the models for confounders.

Table 23. Associations between PI and the likelihood of separation anxiety, social anxiety, generalized anxiety disorder and depression at age 7

|  | Univariable |  |  | Multivariable |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $N$ | OR (95\% CI) | $p$ | $N$ | OR (95\% CI) | $p$ |
| Separation Anxiety | 4969 |  |  | 4442 |  |  |
| Often looks after pets |  | 1 |  |  | 1 |  |
| Occasionally |  | 1.03 (0.73, 1.45) | 0.885 |  | 1.03 (0.71, 1.51) | 0.862 |
| Not at all |  | 1.16 (0.83, 1.60) | 0.384 |  | 1.17 (0.81, 1.68) | 0.401 |
| Social Anxiety | 5370 |  |  | 4442 |  |  |
| Often looks after pets |  | 1 |  |  | 1 |  |
| Occasionally |  | 0.80 (0.57, 1.13) | 0.202 |  | 0.82 (0.57, 1.19) | 0.309 |
| Not at all |  | 0.79 (0.58, 1.09) | 0.164 |  | 0.75 (0.53, 1.08) | 0.120 |


|  | Univariable |  |  |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $N$ | OR (95\% CI) | $p$ | $N$ | OR (95\% CI) | $p$ |
| Generalized Anxiety | 5404 |  |  | 4819 |  |  |
| Often looks after pets |  | 1 |  |  | 1 |  |
| Occasionally |  | 1.06 (0.79, 1.41) | 0.709 |  | 1.15 (0.83, 1.59) | 0.396 |
| Not at all |  | 0.97 (0.74, 1.29) | 0.868 |  | 1.04 (0.76, 1.42) | 0.804 |
| Depression | 5366 |  |  | 4785 |  |  |
| Often looks after pets |  | 1 |  |  | 1 |  |
| Occasionally |  | 0.91 (0.71, 1,16) | 0.442 |  | $0.91(0.69,1.18)$ | 0.480 |
| Not at all |  | 0.93 (0.74, 1.17) | 0.555 |  | 0.95 (0.73, 1.22) | 0.657 |

Analyses adjusted for: sex, maternal depression measured at child age 8 years, maternal anxiety measured at child age 6 years, overcrowding (child age 7 years), house type (child age 7 years), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at child age 3 years, and maternal bonding measured at child age 3 years

Figure 18. Flow chart depicting sample sizes and derivation for behaviour


### 6.2 Behavioural Development

The next sub-section addresses the aim of examining whether there is an association between PO and behavioural outcomes. Prevalence of child behavioural difficulties in the study population are presented in Table 24 . These prevalence rates of behaviour issues in ALSPAC children are high compared to national data for any behavioural disorder which stands at 5\% in children aged 5-10 years, and 6\% for children aged 11-16 years (NHS Digital, 2018). However slightly higher prevalence rates for behavioural disorders (10-15\%) have been reported internationally for children and adolescents (World Health Organization, 2019). It is important to note that the RRS measured at age 3 was derived as a symptom score, not a disorder prevalence (see chapter 6).

Table 24. Prevalence of child behavioural health difficulties in the study population

|  | $N(\%)$ |  |
| :---: | :---: | :---: |
| Outcome | Age 3 (RRS) | Age 11 (SDQ) |
| Emotional Difficulties | $4593(46)$ | $913(12)$ |
| Hyperactivity | $4775(48)$ | $882(12)$ |
| Conduct Difficulties | $4969(57)$ | $1177(16)$ |
| Prosocial Difficulties | $3976(44)$ | $541(7)$ |
| Peer Problems | -- | $1158(16)$ |
| Total Difficulties | $3932(39)$ | $712(10)$ |

## Behaviour

There was no evidence of an association between PO and the likelihood of emotional health difficulties at ages 3 or 11 (Table 25).

At age 3, there was an association between owning cats and higher odds of hyperactivity (OR $1.12,95 \%$ CI $1.01-1.24 ; p=.037$ ) that remained after adjusting the models for confounders.

Owning pets (OR 1.14, 95\% CI 1.05-1.25; p=.003) and cats (OR 1.17, 95\% CI 1.06-1.29; $p=.001$ ) at age 3, and dogs at ages 3 (OR 1.19, 95\% CI 1.07-1.33; $p=$ .002) and 11 (OR 1.44, $95 \%$ CI 1.11-1.86; $p=.006$ ) was associated with a higher likelihood of conduct disorder.

However, owning 'other/miscellaneous' pets at age 3 was associated with lower likelihood of experiencing prosocial difficulties (OR $0.88,95 \%$ CI 0.79-0.97; $p=.012)$ and at age 11 , was associated with a lower likelihood of experiencing peer problems (OR 0.72, 95\% CI 0.57-0.89; p= .004) and a lower likelihood of total behavioural difficulties (OR 0.73, 95\% CI 0.53-0.99; $p=.044$ ).

### 6.2.1 Pet Ownership history

There was no evidence of an association between pet history (sometimes or always owned pets up to 11 years) and behavioural difficulties symptoms at 11 years (Table 26).

Table 25. Univariable and multivariable associations between pet ownership at ages 3 and 11 years and behavioural difficulties and ages 3 and 11 years




|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
|  | Peer Problems |  |  |  |  |  |
| 11 | Has any Pet | 2644 | 0.93 (0.72, 1.20) | 0.574 | 0.93 (0.71, 1.22) | 0.593 |
|  | Has Dog | 2647 | 1.15 (0.91, 1.45) | 0.233 | 1.16 (0.91, 1.49) | 0.234 |
|  | Has Cat | 2648 | 1.19 (0.96, 1.49) | 0.113 | 1.17 (0.93, 1.47) | 0.192 |
|  | Has other/miscellaneous pets | 2647 | 0.73 (0.59, 0.91) | 0.004* | 0.72 (0.57, 0.89) | 0.004* |



|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Total Behavioural Difficulties |  |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |  |
| 3 |  | 8963 | 1.04 (0.95, 1.13) | 0.435 | 1.07 (0.97, 1.17) | 0.167 |
| 11 |  | 2643 | 1.23 (0.84, 1.79) | 0.282 | 1.15 (0.77, 1.72) | 0.506 |
| Has Dog |  |  |  |  |  |  |
| 3 |  | 8956 | 1.04 (0.94, 1.16) | 0.465 | 1.05 (0.93, 1.17) | 0.450 |
| 11 |  | 2646 | 1.33 (0.97, 1.82) | 0.079 | 1.29 (0.92, 1.80) | 0.141 |
| Has Cat |  |  |  |  |  |  |
| 3 |  | 8956 | 1.06 (0.96, 1.16) | 0.251 | 1.07 (0.97, 1.19) | 0.181 |
| 11 |  | 2647 | 1.29 (0.96, 1.75) | 0.090 | 1.21 (0.88, 1.66) | 0.242 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 3 |  | 8956 | 0.95 (0.87, 1.04) | 0.294 | 0.98 (0.88, 1.08) | 0.615 |
| 11 |  | 2646 | 0.79 (0.59, 1.06) | 0.116 | 0.73 (0.53, 0.99) | 0.044* |

Analyses adjusted for: sex, birthweight, maternal depression measured at child age 2 and 11 years, maternal anxiety measured at child age 2 and 11 years, overcrowding (child age 2 and 10 years), highest parental social class, maternal education, maternal age at delivery, family income, housing defects, financial difficulties, home ownership status, car ownership, developmental delay measured at child age 30 months, child
temperament at 2 years, older children living with child, stressful life events at child age 2 and 11 years and maternal bonding measured at child age 3 years.

Pet Ownership History

Table 26. Univariable and multivariable associations (binary logistic regression) between pet ownership history (always, sometimes owned pets up to 11 years) and behavioural outcomes at 11 years

|  |  | Univariable | Multivariable |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Pet ownership | $N$ | OR $(95 \% \mathrm{CI})$ | $p$ | OR (95\% CI) | $p$ |
| history |  |  |  |  |  |


|  | Emotional difficulties |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
| Sometimes | 2002 | 1 | 1 |  |
| Always |  |  | $1.11(0.82,1.50)$ | 0.497 |

## Conduct disorder

| Sometimes | 2002 | 1 |  | 1 |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Always | Hyperactivity |  | $1.37(1.04,1.81)$ | $0.024^{*}$ | $1.26(0.94,1.69)$ | 0.120 |
|  |  |  |  |  |  |  |
| Sometimes | 2000 | 1 |  | 1 |  |  |
| Always |  | $1.06(0.76,1.48)$ | 0.736 | $1.05(0.73,1.50)$ | 0.799 |  |


|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Pet ownership | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| history |  |  |  |  |  |
| Peer Problems |  |  |  |  |  |
| Sometimes | 2002 | 1 |  | 1 |  |
| Always |  | 0.96 (0.76, 1.24) | 0.798 | 0.98 (0.75, 1.27) | 0.851 |
| Prosocial |  |  |  |  |  |
| Sometimes | 2003 | 1 |  | 1 |  |
| Always |  | 0.79 (0.54, 1.17) | 0.247 | 0.88 (0.58, 1.32) | 0.526 |
| Total behaviour difficulties |  |  |  |  |  |
| Sometimes | 2002 | 1 |  | 1 |  |
| Always |  | 1.07 (0.76, 1.52) | 0.695 | $0.94(0.65,1.37)$ | 0.754 |

Analyses adjusted for: sex, birthweight, maternal depression measured at child age 2 and 11 years, maternal anxiety measured at child age 2 and 11 years, overcrowding (child age 2 and 10 years), highest parental social class, maternal education, maternal age at delivery, family income, housing defects, financial difficulties, home ownership status, car ownership, developmental delay measured at child age 30 months, child temperament at 2 years, older children living with child, stressful life events at child age 2 and 11 years and maternal bonding measured at child age 3 years.

## Prosocial behaviour

There are controversies with assessing prosocial behavior as a disorder, as effects may be missed. To understand whether pet ownership is associated with prosocial behavior on a symptom continuum in the ALSPAC population, the analyses were repeated using linear regression on continuous RRS scores (Table 27).

We found that owning a dog was associated with higher prosocial behaviour score $(\mathrm{b}=.24, \mathrm{t}(21)=2.62, \mathrm{p}=.004)$. However, the confidence limits were fairly wide between 0.06 and 0.41 (Table 27). We also found an association between owning other/miscellaneous pets $(\mathrm{b}=.18, \mathrm{t}(22)=2.32, \mathrm{p}=.021)$ and a higher prosocial behaviour score at age 3 .

Table 27. Univariable and multivariable associations between pet ownership at ages 3 and 11, and prosocial behaviour scores at ages 3 and 11 years.

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Has any Pet |  |  |  |  |  |
| 3 | 8980 | 0.18 (0.03, 0.33) | 0.022* | 0.09 (-0.05, 0.23) | 0.197 |
| 11 | 2645 | -0.09 (-0.24, 0.06) | 0.234 | -0.22 (-0.37, -0.07) | 0.057 |
| Has Dog |  |  |  |  |  |
| 3 | 8973 | 0.29 (0.09, 0.47) | 0.003* | 0.24 (0.06, 0.41) | 0.004* |
| 11 | 2648 | -0.04 (-0.17, 0.10) | 0.617 | -0.11 (-0.25, 0.03) | 0.117 |
| Has Cat |  |  |  |  |  |
| 3 | 8973 | -0.01 (-0.17, 0.16) | 0.945 | -0.04 (-0.19, 0.11) | 0.623 |
| 11 | 2649 | -0.09 (-0.22, 0.04) | 0.153 | -0.12 (-0.25, 0.01) | 0.065 |
| Has other/miscellaneous pets |  |  |  |  |  |
| 3 | 8973 | 0.26 (0.09, 0.42) | 0.002* | 0.18 (0.03, 0.33) | 0.021* |
| 11 | 2648 | 0.01 (-0.11, 0.13) | 0.876 | -0.08 (-0.20, 0.05) | 0.222 |

Analyses adjusted for: sex, birthweight, maternal depression measured at child age 2 and 11 years, maternal anxiety measured at child age 2 and 11 years, overcrowding (child age 2 and 10 years), highest parental social class, maternal education, maternal age at delivery, family income, housing defects, financial difficulties, home ownership status, car ownership, developmental delay measured at child age 30 months, child temperament at 2 years, older children living with child, stressful life events at child age 2 and 11 years and maternal bonding measured at child age 3 years.

## Chapter VII

Results: Cognitive, Educational and Language Development

This chapter aims to explore the association between pet ownership and cognitive, educational and language developmental outcomes. It presents the cognitive (attention, impulsivity and memory), educational attainment (KS1, KS2, GCSE) and language development results (comprehension, communication, vocabulary, non-verbal communication and social development). It finds some evidence of an association between pet ownership and educational and language outcomes. Imputed data are presented. Results were consistent between complete-case and imputed datasets (see appendices).

### 7.1 Cognitive Development

The next sub-section of this chapter addresses the aim of examining whether there is an association between pet ownership and cognitive outcomes. Descriptive statistics for attention, impulsivity and memory tasks are presented in Table 28.

Similar scores were obtained for children with and without pets for all tasks.

Figure 19. Flow chart depicting sample sizes and derivation for cognition age 8


Figure 20. Flow chart depicting sample sizes and derivation for cognition at age 10


Figure 21. Flow chart depicting sample sizes and derivation for cognition at age 11


Table 28. Descriptive statistics for attention, impulsivity and memory tasks

| Cognitive task | Has Pets |  | Has Dog |  | Has Cat |  | Has Other Pets |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Yes | No | Yes | No | Yes | No | Yes | No |
| Sky Search Task score | Mean (SD) |  |  |  |  |  |  |  |
| Age 8 | 5.18 | 5.19 | 5.23 | 5.17 | 5.17 | 5.19 | 5.15 | 5.22 |
|  | (1.86) | (1.72) | (1.89) | (1.81) | (1.71) | (1.87) | (1.89) | (1.75) |
| Age 11 | 3.39 | 3.42 | 3.41 | 3.39 | 3.35 | 3.43 | 3.36 | 3.45 |
|  | (1.13) | (0.92) | (1.17) | (1.06) | (1.10) | (1.07) | (1.08) | (1.09) |
| Dual task score | Median |  |  |  |  |  |  |  |
| Age 8 | 2.07 | 2.00 | 2.29 | 1.99 | 2.17 | 2.00 | 2.04 | 2.08 |
| Age 11 | 0.37 | 0.35 | 0.47 | 0.32 | 0.35 | 0.37 | 0.32 | 0.40 |
|  | Mean (SD) |  |  |  |  |  |  |  |
| Same worlds reaction time |  |  |  |  |  |  |  |  |
| Age 8 | 13.09 | 13.16 | 13.25 | 13.07 | 13.10 | 13.11 | 13.06 | 13.18 |
|  | (2.77) | (3.84) | (2.93) | (3.12) | (2.64) | (3.26) | (2.75) | (3.42) |
| Age 11 | 9.87 | 9.90 | 9.95 | 9.85 | 9.88 | 9.87 | 9.82 | 9.95 |
|  | (1.71) | (1.80) | (1.63) | (1.76) | (1.75) | (1.71) | (1.63) | (1.83) |


| Cognitive task | Has Pets |  | Has Dog |  | Has Cat |  | Has Other Pets |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Yes | No | Yes | No | Yes | No | Yes | No |
| Opposite worlds reaction time |  |  |  |  |  |  |  |  |
| Age 8 | 13.09 | 13.16 | 13.26 | 17.39 | 13.10 | 13.12 | 13.06 | 17.61 |
|  | $(2.77)$ | $(3.84)$ | $(2.92)$ | $(6.36)$ | $(2.64)$ | $(3.26)$ | $(2.75)$ | $(7.58)$ |
| Age 11 | 12.37 | 12.36 | 12.45 | 12.34 | 12.41 | 12.35 | 12.28 | 12.48 |
|  | $(2.40)$ | $(2.25)$ | $(2.08)$ | $(2.46)$ | $(2.54)$ | $(2.27)$ | $(2.19)$ | $(2.57)$ |
| Stop- signal 150ms delay |  |  |  |  |  |  |  |  |
| Age 10 | 12.06 | 12.00 | 12.05 | 12.04 | 12.06 | 12.04 | 12.14 | 11.96 |
|  | $(3.08)$ | $(3.14)$ | $(3.10)$ | $(3.09)$ | $(3.04)$ | $(3.11)$ | $(3.01)$ | $(3.17)$ |
| Stop-signal 250ms delay |  |  |  |  |  |  |  |  |
| Age 10 | 13.66 | 13.58 | 13.58 | 13.66 | 13.65 | 13.63 | 13.69 | 13.59 |
|  | $(2.65)$ | $(2.75)$ | $(2.69)$ | $(2.67)$ | $(2.57)$ | $(2.73)$ | $(2.64)$ | $(2.71)$ |
| Digit-span task score |  |  |  |  |  |  |  |  |
| Age 8 | 12.91 | 13.04 | 12.64 | 13.02 | 12.89 | 12.97 | 12.90 | 12.99 |
|  | $(2.91)$ | $(2.97)$ | $(2.85)$ | $(2.93)$ | $(2.93)$ | $(2.92)$ | $(2.92)$ | $(2.93)$ |
|  | Age 10 | 3.41 | 3.46 | 3.34 | 3.45 | 3.41 | 3.44 | 3.40 |
|  |  | $(0.84)$ | $(0.86)$ | $(0.83)$ | $(0.85)$ | $(0.86)$ | $(0.84)$ | $(0.83)$ |

At ages 8 and 11 there was no association between PO and selective attention, or attentional control (Table 2). However, owning a dog was associated with a poorer ability in attentional switching $(\mathrm{b}=0.42,95 \% C I-0.65,1.56, \mathrm{p}=.005)$ that remained after adjusting the models for confounders. This association remained after accounting for scores at both time points within a repeated measures model $(\mathrm{b}=0.67,95 \% ~ C I$ $0.25-1.08, \mathrm{p}=.001$ ) (Table 30).

There was no evidence of an association between PO and impulsivity or working memory (Table 29).

### 7.1.1 Pet Ownership History

There was no association between pet history (sometimes or always owning pets up to 11 years) and cognition at 11 years (Table 31).

Table 29. Univariable and multivariable associations between pet ownership at ages 8,10 and 11 , and attention, impulsivity and memory tasks


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
|  | Attentional Switching (Dual Task) |  |  |  |  |  |
|  | Has any Pet |  |  |  |  |  |
| 8 |  | 5228 | 0.32 (-0.72, 1.35) | 0.548 | 0.71 (-0.32, 1.75) | 0.178 |
| 11 |  | 2357 | 0.15 (-0.15, 0.46) | 0.326 | 0.27 (-0.05, 0.59) | 0.098 |
|  | Has Dog |  |  |  |  |  |
| 8 |  | 5228 | 0.46 (-0.64, 1.55) | 0.414 | 0.46 (-0.65, 1.56) | 0.417 |
| 11 |  | 2359 | $0.39(0.10,0.67)$ | 0.007* | 0.42 (0.12, 0.71) | 0.005* |
|  | Has Cat |  |  |  |  |  |
| 8 |  | 5228 | 0.49 (-0.48, 1.47) | 0.325 | 0.65 (-0.33, 1.62) | 0.192 |
| 11 |  | 2360 | $0.01(-0.26,0.27)$ | 0.950 | 0.05 (-0.22, 0.32) | 0.715 |
|  | Has other/miscellaneous pets |  |  |  |  |  |
| 8 |  | 5228 | -0.35 (-1.25, 0.56) | 0.459 | -0.06 (-0.97, 0.85) | 0.894 |
| 11 |  | 2359 | -0.08 (-0.33, 0.17) | 0.559 | -0.01 (-0.26, 0.25) | 0.991 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Attentional Control |  |  |  |  |  |  |
| Same worlds task |  |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |  |
| 8 |  | 5745 | -0.06 (-0.25, 0.12) | 0.477 | -0.03 (-0.21, 0.16) | 0.773 |
| 11 |  | 2448 | -0.03 (-0.20, 0.14) | 0.715 | 0.03 (-0.14, 0.20) | 0.723 |
| Has Dog |  |  |  |  |  |  |
| 8 |  | 5746 | 0.18 (-0.01, 0.38) | 0.055 | 0.16 (-0.04, 0.35) | 0.111 |
| 11 |  | 2450 | 0.09 (-0.06, 0.25) | 0.236 | $0.07(-0.09,0.23)$ | 0.376 |
| Has Cat |  |  |  |  |  |  |
| 8 |  | 5746 | -0.02 (-0.19, 0.16) | 0.867 | -0.01 (-0.17, 0.17) | 0.966 |
| 11 |  | 2451 | 0.01 (-0.14, 0.15) | 0.910 | 0.02 (-0.12, 0.17) | 0.778 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 8 |  | 5746 | -0.13 (-0.28, 0.04) | 0.126 | -0.09 (-0.25, 0.07) | 0.268 |
| 11 |  | 2450 | -0.13 (-0.26, 0.01) | 0.071 | -0.08 (-0.22, 0.06) | 0.250 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Opposite worlds task |  |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |  |
| 8 |  | 5739 | -0.33 (-0.67, 0.02) | 0.068 | -0.27 (-0.63, 0.08) | 0.126 |
| 11 |  | 2446 | 0.01 (-0.22, 0.25) | 0.911 | 0.14 (-0.09, 0.38) | 0.232 |
| Has Dog |  |  |  |  |  |  |
| 8 |  | 5740 | 0.23 (-0.14, 0.59) | 0.231 | 0.16 (-0.21, 0.53) | 0.400 |
| 11 |  | 2448 | 0.11 (-0.10, 0.32) | 0.303 | 0.09 (-0.12, 0.31) | 0.389 |
| Has Cat |  |  |  |  |  |  |
| 8 |  | 5740 | -0.07 (-0.40, 0.26) | 0.686 | $-0.05(-0.38,0.28)$ | 0.764 |
| 11 |  | 2449 | 0.06 (-0.14, 0.25) | 0.580 | $0.11(-0.09,0.30)$ | 0.282 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 8 |  | 5740 | -0.31 (-0.62, -0.01) | 0.047* | -0.26 (-0.56, 0.05) | 0.105 |
| 11 |  | 2448 | -0.19 (-0.37, 0.00) | 0.050* | -0.11 (-0.29, 0.08) | 0.268 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
|  | Impulsivity |  |  |  |  |  |
| $10 \quad$Stop-signal task 150ms <br> delay |  |  |  |  |  |  |
|  | Has any Pet | 5729 | 0.07 (-0.12, 0.25) | 0.464 | 0.45 (-0.15, 0.24) | 0.655 |
|  | Has Dog | 5729 | 0.07 (-0.12, 0.25) | 0.464 | -0.04 (-0.23, 0.16) | 0.727 |
|  | Has Cat | 5728 | $0.02(-0.15,0.19)$ | 0.850 | $0.02(-0.16,0.20)$ | 0.810 |
|  | Has other/miscellaneous pets | 5728 | 0.18 (0.02, 0.34) | 0.028* | 0.16 (-0.01, 0.33) | 0.057 |
| 10Stop-signal task 250ms <br> delay |  |  |  |  |  |  |
|  | Has any Pet | 5729 | 0.08 (-0.08, 0.24) | 0.344 | 0.04 (-0.13, 0.20) | 0.659 |
|  | Has Dog | 5728 | -0.07 (-0.23, 0.09) | 0.382 | -0.10 (-0.27, 0.07) | 0.245 |
|  | Has Cat | 5728 | $0.02(-0.12,0.17)$ | 0.747 | $0.02(-0.14,0.17)$ | 0.847 |
|  | Has other/miscellaneous pets | 5728 | $0.11(-0.03,0.25)$ | 0.132 | 0.07 (-0.07, 0.22) | 0.321 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Working Memory |  |  |  |  |  |  |
| Digit span task |  |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |  |
| 8 |  | 5749 | -0.51 (-16.06, 15.05) | 0.989 | -2.56 (-18.26, 13.14) | 0.749 |
| 10 |  | 5760 | 11.21 (-2.31, 24.72) | 0.104 | 3.77 (-8.37, 15.91) | 0.543 |
| Has Dog |  |  |  |  |  |  |
| 8 |  | 5749 | -1.60 (-18.08, 14.88) | 0.849 | -3.55 (-20.31, 13.20) | 0.678 |
| 10 |  | 5759 | 6.79 (-6.89, 20.50) | 0.330 | 3.62 (-8.92, 16.16) | 0.571 |
| Has Cat |  |  |  |  |  |  |
| 8 |  | 5749 | -6.26 (-21.01, 8.50) | 0.406 | -8.14 (-22.93, 6.65) | 0.281 |
| 10 |  | 5759 | -0.37 (-13.02, 12.28) | 0.955 | -3.82 (-15.19, 7.55) | 0.510 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 8 |  | 5749 | 0.98 (-12.71, 14.68) | 0.888 | -0.77 (-14.60, 13.05) | 0.912 |
| 10 |  | 5759 | 3.19 (-8.61, 14.99) | 0.596 | -1.01 (-11.71, 9.51) | 0.839 |

Analyses were adjusted for: sex, maternal depression at ages 8 and 11 years, maternal anxiety at ages 6 and 11 years, overcrowding at 8 and 10 years, house type at ages 7 and 10 years, highest parental social, maternal education, maternal age at delivery, home ownership status, family
income and car ownership, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old, and mother-child bonding at child age 3 years.

Table 30. Univariable and multivariable random effects hierarchical model for dog ownership and dual task score

|  | Unadjusted <br> estimate | Unadjusted CI | $P$ | Adjusted <br> estimate | Adjusted CI |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Dual task |  |  |  |  |  |
| (intercept) | 11.25 | $10.34-12.16$ |  | ref | $9.18-16.77$ |
| No | ref |  |  | 0.67 | $0.25-1.08$ |
| Yes | 0.40 | $0.12-0.67$ | 0.004 |  | 0.001 |

Analyses were adjusted for: sex, maternal depression at ages 8 and 11 years, maternal anxiety at ages 6 and 11 years, overcrowding at 8 and 10 years, house type at ages 7 and 10 years, highest parental social, maternal education, maternal age at delivery, home ownership status, family income and car ownership, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old, and mother-child bonding at child age 3 years.

Table 31. Univariable and multivariable associations between pet ownership history (always, sometimes owned pets up to 11 years) and cognitive outcomes (attention) at 11 years.

|  | Univariable |  | Multivariable |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Pet ownership history | N | $\mathrm{B}(95 \% \mathrm{CI})$ | $p$ | $\mathrm{~B}(95 \% C I)$ | $p$ |
| Sky Search | 1854 | $-0.09(-0.19,0.01)$ | 0.054 | $-0.08(-0.18,0.02)$ | 0.112 |
| Attentional switching (Dual | 1742 | $0.25(-0.07,0.57)$ | 0.131 | $0.28(-0.05,0.60)$ | 0.098 |
| task) |  |  |  |  |  |
| Same worlds task | 1803 | $0.15(-0.01,0.31)$ | 0.071 | $0.07(-0.09,0.24)$ | 0.364 |
| Opposite worlds task | 1802 | $0.20(-0.02,0.43)$ | 0.077 | $0.11(-0.12,0.34)$ | 0.342 |

Analyses were adjusted for: sex, maternal depression at 11 years, maternal anxiety at 11 years, overcrowding at 10 years, house type at 10 years, highest parental social, maternal education, maternal age at delivery, home ownership status, family income and car ownership, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at 11 years old, and mother-child bonding at child age 3 years.

### 7.2 Educational Development

Descriptive statistics for Key Stage 1 (age 7), Key Stage 2 (age 11) and Key Stage 4/ General Certificate of Secondary Education (age 16) educational attainment separated by PO status are presented in Table 32.

Figure 22. Flow chart depicting sample sizes and derivation for Education


Table 32. Descriptive statistics for KS1, KS2 and GCSE educational attainment

| Exam | Mean (SD) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Has Pets |  | Has Dog |  | Has Cat |  | Has other pets |  |
|  | Yes | No | Yes | No | Yes | No | Yes | No |
| KS1 |  |  |  |  |  |  |  |  |
| Reading | 3.54 (1.42) | 3.71 (1.36) | 3.30 (1.46) | 3.67 (1.38) | 3.55 (1.42) | 3.61 (1.40) | 3.55 (1.42) | 3.61 (1.39) |
| Writing | 2.83 (1.19) | 3.00 (1.19) | 2.64 (1.18) | 2.95 (1.19) | 2.84 (1.19) | 2.89 (1.19) | 2.84 (1.19) | 2.89 (1.19) |
| Maths | 3.46 (1.30) | 3.59 (1.27) | 3.29 (1.32) | 3.55 (1.28) | 3.43 (1.30) | 3.52 (1.29) | 3.43 (1.30) | 3.52 (1.29) |
| Total | 9.83 (3.51) | 10.31 (3.45) | 9.23 (3.55) | 10.17 (3.45) | 9.82 (3.53) | 10.03 (3.48) | 9.82 (3.53) | 10.03 (3.48) |
| KS2 |  |  |  |  |  |  |  |  |
| English | 65.33 (13.54) | 65.25 (13.89) | 63.34 (13.28) | 66.06 (13.67) | 64.87 (13.93) | 65.56 (13.45) | 65.84 (13.43) | 64.70 (13.82) |
| Maths | 72.48 (18.04) | 74.45 (18.87) | 70.40 (18.08) | 73.82 (18.21) | 71.29 (18.52) | 73.72 (18.04) | $72.91 \text { (17.91) }$ | $72.88 \text { (19.01) }$ |
| Science | 63.94 (10.01) | 64.53 (10.24) | 62.64 (10.19) | 64.60 (9.95) | 63.27 (10.43) | 64.48 (9.83) | $64.30 \text { (9.66) }$ | 63.79 (10.51) |
| Total | 90.86 (10.58) | 90.78 (13.44) | 89.26 (12.33) | 91.47 (10.70) | 90.18 (9.56) | 91.20 (11.97) | 91.48 (10.50) | 90.11 (11.98) |


| GCSE | $\mathbf{N ( \% )}$ |  |  |  |  |  |  |  |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| English A*/A | $547(30)$ | $226(34)$ | $207(25)$ | $567(33)$ | $245(30)$ | $529(31)$ | $285(28)$ | $488(33)$ |
| Maths A*/A | $564(25)$ | $232(36)$ | $218(27)$ | $578(35)$ | $239(30)$ | $557(34)$ | $315(31)$ | $479(33)$ |
| Biological Sciences | $237(55)$ | $109(69)$ | $103(54)$ | $243(61)$ | $108(56)$ | $238(60)$ | $120(50)$ | $225(65)$ |
| A*/A |  |  |  |  |  |  |  |  |
| Chemistry A*/A | $224(54)$ | $109(70)$ | $97(52)$ | $236(60)$ | $99(53)$ | $234(60)$ | $116(50)$ | $216(63)$ |
| Physics A*/A | $229(55)$ | $105(67)$ | $102(55)$ | $232(59)$ | $104(55)$ | $230(59)$ | $119(52)$ | $215(63)$ |
| Achieved 5+ GCSEs | $1624(73)$ | $605(78)$ | $701(68)$ | $1532(77)$ | $734(72)$ | $1499(75)$ | $895(74)$ | $1338(74)$ |
| A*-C |  |  |  |  |  |  |  |  |

KS1 $=$ Key Stage 1, KS2 $=$ Key Stage 2, GCSE $=$ General Certificate of Secondary Education.
KS1 scores: W (working towards level 1 ) $=0,1=1,2 \mathrm{C}=2,2 \mathrm{~B}=3,2 \mathrm{~A}=4,3 / 4+=5$. KS2 English: $\mathrm{N}=0-25$ marks, Level $2=26-28$ marks, Level $3=29-48$ marks, Level $4=49-70$ marks, Level $5=71-100$ marks. KS2 Maths: $N=0-17$ marks, Level 2 $=18-20$ marks, Level $3=21-48$ marks, Level $4=49-77$ marks, Level $5=78-100$ marks. KS2 Science: $N=0-17$ marks, Level $2=18-20$ marks, Level $3=21-39$ marks, Level $4=$ 40-63 marks, Level $5=64-80$ marks.

KS1 and KS2 level attainment within ALSPAC are equivalent to national averages (Table 32). However children in ALSPAC have a higher GCSE attainment at the age of 16 years in comparison to the National Pupil Database (NPD) 'Key Stage 4’ (KS4) national sample dataset records (Boyd et al., 2013).

At KS1 owning pets, dogs and other pets were associated with poorer attainment in reading (pets $\mathrm{b}=-0.09, \mathrm{p}=.012$; dogs $\mathrm{b}=-0.17, \mathrm{p}<.001$; other pets $\mathrm{b}=$ $-0.12, \mathrm{p}<.001$ ), writing (pets $\mathrm{b}=-0.13, \mathrm{p}=.001$; dogs $\mathrm{b}=-0.15, \mathrm{p}<.001$; other pets b $=-0.12, \mathrm{p}$ <.001), maths (pets $\mathrm{b}=-0.07, \mathrm{p}=.041$; dogs $\mathrm{b}=-0.09, \mathrm{p}=.015$; other pets $\mathrm{b}=-0.08, \mathrm{p}=.013$ ) and total summary scores (pets $\mathrm{b}=-0.29, \mathrm{p}=.002$; dogs $\mathrm{b}=-0.41$, p <.001; other pets $\mathrm{b}=-0.32, \mathrm{p}$ <.001) (Table 33), however these were very small effects. Cat ownership was not associated with KS1 attainment. (Table 33).

At KS2, owning a dog was associated with poorer attainment in English (b = 1.75, $\mathrm{p}=.007$ ), Maths ( $\mathrm{b}=-2.27, \mathrm{p}=.009$ ) and Science $(\mathrm{b}=-1.04, \mathrm{p}=.028)$. Owning cats was associated with a poorer attainment in Maths $(\mathrm{b}=-1.91, \mathrm{p}=.015)$ and Science ( $\mathrm{b}=-1.20, \mathrm{p}=.005$ ) (Table 33).

At GCSE, all pet types were associated with poorer attainment in a variety of subjects (Table 33).

Owning any pet was associated with a lower likelihood of achieving top grades in Biological sciences (OR 0.63, 95\% CI 0.39-0.99; $p=\cdot 048$ ), and Chemistry ( $O R$ 0.46, $95 \%$ CI 0.29-0.73; $p=\cdot 001$ ).

Owning a dog was associated with a lower likelihood of achieving top grades in English (OR 0.75, 95\% CI 0.59-0.94; p= .014), Maths (OR 0.67, 95\% CI 0.54-0.85; $p=\cdot 001$ ), Chemistry (OR 0.63, 95\% CI 0.40-0.99; $p=\cdot 049$ ) and a lower likelihood of achieving five GCSEs A*-C (OR 0.76, 95\% CI 0.60-0.96; $p=\cdot 023$ ).

Owning a cat was associated with a lower likelihood of achieving top grades in Maths $($ OR $0.79,95 \% ~ C I ~ 0.63-0.98 ; ~ p=.035) . ~$

Owning other pets was associated with a lower likelihood of achieving top grades in Biological science (OR 0.61, $95 \%$ CI $0.40-0.92 ; p=\cdot 019$ ), and Chemistry (OR 0.56, 95\% CI 0.37-0.84; $p=\cdot 005$ ).

Table 33. Univariable and multivariable associations between pet ownership at ages 7, 11 and 15, and KS1, KS2 and GCSE attainment

|  |  | Univariable linear association using continuous grade score |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| KS1 |  |  |  |  |  |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Reading |  |  |  |  |  |
| Has any Pet | 5760 | -0.20 (-0.28, -0.11) | <0.001* | -0.09 (-0.17, -0.02) | 0.012* |
| Has Dog | 5755 | -0.36 (-0.46, -0.27) | <0.001* | -0.17 (-0.25, -0.08) | $<0.001 *$ |
| Has Cat | 5755 | -0.05 (-0.14, 0.03) | 0.228 | -0.01 (-0.09, 0.06) | 0.726 |
| Has other/miscellaneous pets | 5755 | -0.19 (-0.27, -0.12) | $<0.001 *$ | -0.12 (-0.19, -0.06) | $<0.001^{*}$ |
| Writing |  |  |  |  |  |
| Has any Pet | 5762 | -0.21 (-0.29, -0.14) | <0.001* | -0.13 (-0.19, -0.06) | <0.001* |
| Has Dog | $5757$ | $-0.31(-0.39,-0.23)$ | $<0.001 *$ | $-0.15(-0.22,-0.08)$ | $<0.001^{*}$ |
| Has Cat | 5757 | -0.08 (-0.15, -0.01) | 0.035* | -0.04 (-0.10, 0.02) | 0.170 |
| Has other/miscellaneous pets | 5757 | -0.16 (-0.23, -0.09) | <0.001* | -0.12 (-0.17, -0.06) | $<0.001^{*}$ |


|  |  | Univariable linear association using continuous grade score |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| KS1 |  |  |  |  |  |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Maths |  |  |  |  |  |
| Has any Pet | 5754 | -0.16 (-0.24, -0.08) | <0.001* | -0.07 (-0.14, -0.00) | 0.041* |
| Has Dog | 5749 | -0.25 (-0.34, -0.16) | <0.001* | -0.09 (-0.17, -0.02) | 0.015* |
| Has Cat | 5749 | -0.11 (-0.18, -0.03) | 0.007* | -0.07 (-0.13, 0.00) | 0.054 |
| Has other/miscellaneous pets | 5749 | -0.12 (-0.19, -0.04) | 0.002* | -0.08 (-0.14, -0.02) | 0.013* |
| Total summary score |  |  |  |  |  |
| Has any Pet | 5756 | -0.58 (-0.79, -0.36) | <0.001* | -0.29 (-0.47, -0.11) | 0.002* |
| Has Dog | 5756 | -0.93 (-1.16, -0.69) | <0.001* | -0.41 (-0.61, -0.21) | <0.001* |
| Has Cat | 5756 | -0.24 (-0.45, -0.03) | 0.026* | -0.12 (-0.29, 0.05) | 0.174 |
| Has other/miscellaneous pets | 5756 | -0.49 (-0.68, -0.29) | <0.001* | -0.32 (-0.48, -0.15) | <0.001* |


|  |  | Univariable linear association using continuous grade score |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| KS2 |  |  |  |  |  |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| English |  |  |  |  |  |
| Has any Pet | 2035 | -0.08 (-1.56, 1.40) | 0.915 | -0.20 (-1.56, 1.15) | 0.770 |
| Has Dog | 2037 | -2.23 (-3.61, -0.86) | 0.001* | -1.75 (-3.03, -0.47) | 0.007* |
| Has Cat | 2037 | -1.17 (-2.45, 0.11) | 0.072 | $-1.02(-2.18,0.15)$ | 0.087 |
| Has other/miscellaneous pets | 2037 | 0.35 (-0.86, 1.56) | 0.565 | 0.67 (-0.44, 1.79) | 0.237 |
| Maths |  |  |  |  |  |
| Has any Pet | 2028 | -2.48 (-4.41, -0.54) | 0.012* | $-1.34(-3.13,0.45)$ | 0.142 |
| Has Dog | 2029 | -2.95 (-4.75, -1.14) | 0.001* | $-2.27(-3.95,-0.58)$ | 0.009* |
| Has Cat | 2029 | -2.39 (-4.07, -0.71) | 0.005* | -1.91 (-3.44, -0.37) | 0.015* |
| Has other/miscellaneous pets | 2029 | -0.38 (-1.98, 1.21) | 0.640 | -0.02 (-1.48, 1.47) | 0.998 |


|  |  | Univariable linear association using continuous grade score |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| KS2 |  |  |  |  |  |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Science |  |  |  |  |  |
| Has any Pet | 2032 | -0.95-(2.00, 0.10) | 0.077 | -0.36 (-1.34, 0.62) | 0.467 |
| Has Dog | 2034 | -1.55 (-2.54, -0.58) | 0.002* | -1.04 (-1.96, -0.11) | 0.028* |
| Has Cat | 2034 | -1.48 (-2.39, -0.57) | 0.001* | -1.20 (-2.04, -0.37) | 0.005* |
| Has other/miscellaneous pets | 2034 | 0.08 (-0.78, 0.95) | 0.850 | 0.36 (-0.45, 1.16) | 0.387 |
| Total KS2 point score |  |  |  |  |  |
| Has any Pet | 407 | 0.47 (-2.37, 3.31) | 0.743 | -0.40 (-3.06, 2.26) | 0.768 |
| Has Dog | 407 | $-2.36(-5.05,0.32)$ | 0.084 | $-1.63(-4.19,0.94)$ | 0.215 |
| Has Cat | 407 | -1.54 (-4.08, 0.99) | 0.231 | -0.46 (-2.76, 1.84) | 0.698 |
| Has other/miscellaneous pets | 407 | 1.98 (-0.38, 4.34) | 0.100 | 0.61 (-1.59, 2.82) | 0.586 |


|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| GCSE | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Subject |  |  |  |  |  |
| English |  |  |  |  |  |
| Has any Pet | 1990 | 0.85 (0.71, 1.02) | 0.081 | 0.84 (0.67, 1.05) | 0.131 |
| Has Dog | 1993 | 0.63 (0.52, 0.75) | <0.001* | 0.75 (0.59, 0.94) | 0.014* |
| Has Cat | 1993 | 1.03 (0.87, 1.23) | 0.716 | 0.88 (0.071, 1.09) | 0.256 |
| Has other/miscellaneous pets | 1994 | 0.78 (0.66, 0.93) | 0.004* | 0.87 (0.71, 1.08) | 0.203 |
| Maths |  |  |  |  |  |
| Has any Pet | 1919 | 0.76 (0.63, 0.91) | 0.003* | 0.82 (0.66, 1.03) | 0.089 |
| Has Dog | 1922 | 0.57 (0.48, 0.69) | <0.001* | 0.67 (0.54, 0.85) | 0.001* |
| Has Cat | 1922 | 0.85 (0.72, 1.02) | 0.081 | $0.79(0.63,0.98)$ | 0.035* |
| Has other/miscellaneous pets | 1923 | 0.92 (0.77, 1.08) | 0.305 | 1.03 (0.84, 1.27) | 0.770 |
| Biological Sciences |  |  |  |  |  |
| Has any Pet | 490 | 0.65 (0.45, 0.95) | 0.024* | 0.63 (0.39, 0.99) | 0.048* |
| Has Dog | 490 | 0.73 (0.52, 1.04) | 0.084 | 0.76 (0.48, 1.20) | 0.237 |
| Has Cat | 490 | 0.88 (0.63, 1.25) | 0.485 | 0.93 (0.59, 1.45) | 0.750 |
| Has other/miscellaneous pets | 490 | 0.60 (0.43, 0.84) | 0.003* | 0.61 (0.40, 0.92) | 0.019* |


| GCSE |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Chemistry |  |  |  |  |  |
| Has any Pet | 478 | 0.56 (0.38, 0.82) | 0.003* | 0.46 (0.29, 0.73) | 0.001* |
| Has Dog | 478 | 0.65 (0.45, 0.92) | 0.016* | 0.63 (0.40, 0.99) | 0.049* |
| Has Cat | 478 | 0.83 (0.59, 1.17) | 0.287 | 0.79 (0.52, 1.23) | 0.305 |
| Has other/miscellaneous pets | 478 | 0.63 (0.45, 0.88) | 0.007* | 0.56 (0.37, 0.84) | 0.005* |
| Physics |  |  |  |  |  |
| Has any Pet | 475 | 0.76 (0.59, 0.97) | 0.027* | 0.86 (0.64, 1.16) | 0.310 |
| Has Dog | 476 | 0.63 (0.49, 0.80) | <0.001* | 0.83 (0.61, 1.12) | 0.228 |
| Has Cat | 476 | 0.82 (0.65, 1.05) | 0.114 | 0.76 (0.57, 1.03) | 0.075 |
| Has other/miscellaneous pets | 476 | 0.85 (0.68, 1.06) | 0.153 | 1.01 (0.76, 1.34) | 0.935 |
| Achieved 5 GCSEs A*-C |  |  |  |  |  |
| Has any Pet | 2010 | 0.89 (0.72, 1.09) | 0.249 | 0.94 (0.73, 1.21) | 0.634 |
| Has Dog | 2013 | 0.65 (0.54, 0.79) | $<0.001 *$ | 0.76 (0.60, 0.96) | 0.023* |
| Has Cat | 2013 | 1.06 (0.88, 1.29) | 0.527 | 1.02 (0.80, 1.29) | 0.873 |
| Has other/miscellaneous pets | 2014 | 0.89 (0.75, 1.07) | 0.224 | 0.97 (0.78, 1.22) | 0.818 |

Analyses were adjusted for: sex, maternal depression at ages 6,8 and 11 years, maternal anxiety at ages 6 and 11 years, overcrowding at 7 and 10 years, house type at ages 7 and 10 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family
income and car ownership, school identifier, school type, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old, and mother-child bonding at age 3 .

### 7.2.1 Pet Ownership History

When exploring pet ownership history, there was evidence of an association with GCSE attainment (Table 34).

Always owning pets up to 15 years was associated with a lower likelihood of attaining top grades in English (OR 0.79, 95\% CI 0.63-0.99; p= $\cdot 037$ ), and Maths ( $O R$ 0.67, $95 \%$ CI 0.53-0.85; $p=\cdot 001$ ).

Table 34. Univariable and multivariable associations between pet ownership history (always, sometimes owned pets up to 15 years) and GCSE attainment.

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Pet ownership history | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| English | 1714 | 0.62 (0.51, 0.76) | <0.001* | 0.79 (0.63, 0.99) | 0.037* |
| Maths | 1654 | 0.51 (0.41, 0.62) | <0.001* | 0.67 (0.53, 0.85) | 0.001* |
| Biological Sciences | 433 | 0.71 (0.48, 1.05) | 0.089 | 0.87 (0.55, 1.36) | 0.533 |
| Chemistry | 424 | 0.73 (0.49, 1.08) | 0.113 | 0.79 (0.51, 1.24) | 0.315 |
| Physics | 423 | 0.95 (0.64, 1.40) | 0.796 | 1.09 (0.69, 1.71) | 0.694 |
| Achieved 5 GCSEs A*-C | 2021 | 0.64 (0.50, 0.82) | <0.001* | 0.80 (0.61, 1.05) | 0.109 |

Analyses were adjusted for: sex, maternal depression at 11 years, maternal anxiety at 11 years, overcrowding at 10 years, house type at 10 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership, school identifier, school type, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at 11 years old, and mother-child bonding at age 3 .

### 7.2.2 Pet Interaction (KS1)

There was no evidence of an association between PI and KS1 attainment before and after adjusting the models for confounders.

Table 35. Associations between PI and KS1 attainment

|  |  | Univariable |  | Multivariable |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Reading | $N$ | $\mathrm{~B}(95 \% C I)$ | $p$ | $N$ | $\mathrm{~B}(95 \% C I)$ |
| Writing | 6340 | $0.04(-0.02,0.09)$ | 0.166 | 4138 | $0.05(0.01,0.10)$ |
| Maths | 6345 | $0.02(-0.03,0.06)$ | 0.470 | 4141 | $0.02(-0.02,0.07)$ |
| Total KS1 Score | 6342 | $0.03(-0.02,0.07)$ | 0.282 | 4137 | $0.03(-0.02,0.08)$ |

Analyses were adjusted for: sex, maternal depression at age 6 years, maternal anxiety at age 6 years, overcrowding at 7 years, house type at age 7 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership, school identifier, school type, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, and mother-child bonding at age 3

### 7.3 Language Development

Descriptive statistics for language development tests Reynell Developmental Language Scales (RDLS) and the MacArthur Toddler Communication questionnaire (MCDI) are presented in Table 36.

Figure 23. Flow chart depicting sample sizes and derivation for language development


Table 36. Descriptive statistics for Language development scores

|  | Mean (SD) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Has Pets |  | Has Dog |  | Has Cat |  | Has other pets |  |
|  | Yes | No | Yes | No | Yes | No | Yes | No |
| Reynell Developmental Language |  |  |  |  |  |  |  |  |
| Scales |  |  |  |  |  |  |  |  |
| Age 2 | 23.61 | 24.52 | 22.51 | 24.33 | 24.03 | 24.04 | 23.42 | 24.05 |
|  |  |  |  |  |  |  |  | (8.41) |
| Age 5 | 61.08 | 60.76 | 60.94 | 60.92 | 61.01 | 60.92 | 61.06 | 60.88 |
|  | (3.83) | (4.78) | (3.18) | (4.45) | (3.61) | (4.48) | (4.11) | (4.34) |


| MacArthur Toddler Communication <br> questionnaire |  |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Total Communication Score | 127.96 | 126 | 128.26 | 127.31 | 125.48 | 128.29 | 130.00 | 127.43 |
|  | $(51.48)$ | $(51.30)$ | $(53.44)$ | $(50.91)$ | $(50.27)$ | $(51.84)$ | $(48.81)$ | $(51.49)$ |
| Vocabulary Score | 87.08 | 86.57 | 87.51 | 86.72 | 85.08 | 87.57 | 88.61 | 86.83 |
|  | $(44.86)$ | $(44.84)$ | $(46.65)$ | $(44.41)$ | $(43.61)$ | $(45.32)$ | $(42.83)$ | $(44.92)$ |
|  | 14.00 | 13.80 | 14.03 | 13.88 | 13.86 | 13.93 | 14.07 | 13.91 |
| Non-Verbal Communication | $(3.37)$ | $(3.33)$ | $(3.45)$ | $(3.33)$ | $(3.34)$ | $(3.36)$ | $(3.25)$ | $(3.36)$ |
| Score | 17.38 | 17.11 | 17.29 | 17.25 | 17.21 | 17.28 | 17.97 | 17.24 |
| Social Development Score | $(5.69)$ | $(5.54)$ | $(5.70)$ | $(5.61)$ | $(5.65)$ | $(5.62)$ | $(5.62)$ | $(5.63)$ |
|  |  |  |  |  |  |  |  |  |

Owning a pet at age 5 was associated with a higher RDLS score at age 5 ( $\mathrm{b}=$ $1.01, \mathrm{p}=.017$ ) (Table 37). However, this association did not remain in a repeated measures design accounting for scores at both time points $(\mathrm{b}=0.41, \mathrm{p}=.743)$ (Table 38).

Owning a pet at age 2 was also associated with a higher non-verbal communication score within the MacArthur subscale at age $2(\mathrm{~b}=0.18, \mathrm{p}=.014)$ (Table 37).

Table 37. Univariable and multivariable associations between pet ownership at ages 2 and 5, and language development scores.

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Reynell Developmental Language Scale |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |
| 2 | 713 | $-1.17(-2.47,0.13)$ | 0.077 | -0.04 (-1.13, 1.05) | 0.843 |
| 5 | 393 | 0.39 (-0.35, 1.13) | 0.299 | $1.01(0.18,1.83)$ | 0.017* |
| Has Dog |  |  |  |  |  |
| 2 | 712 | -1.89 (-3.71, -0.07) | 0.041* | $-1.09(-2.58,0.39)$ | 0.149 |
| 5 | 393 | -0.24 (-1.25, 0.77) | 0.646 | 0.93 (-0.19, 2.04) | 0.103 |
| Has Cat |  |  |  |  |  |
| 2 | 712 | $-0.78(-2.15,0.60)$ | 0.270 | -0.15 (-1.29, 0.99) | 0.800 |
| 5 | 393 | 0.27 (-0.53, 1.09) | 0.502 | -0.24 (-1.10, 0.63) | 0.595 |
| Has other/miscellaneous pets |  |  |  |  |  |
| 2 | 712 | -2.23 (-6.05, 1.58) | 0.251 | $-2.76(-6.04,0.52)$ | 0.099 |
| $5$ | 393 | 0.65 (-1.33, 2.63) | 0.520 | 0.87 (-1.13, 2.88) | 0.393 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| 2 | Total Communication Score (MacArthur) |  |  |  |  |  |
|  | Has any Pet | 6112 | 1.31 (-1.33, 3.95) | 0.330 | 0.27 (-1.71, 2.25) | 0.787 |
|  | Has Dog | 6105 | -1.01 (-4.43, 2.42) | 0.565 | -1.27 (-3.77, 1.24) | 0.321 |
|  | Has Cat | 6107 | -0.89 (-3.77, 2.00) | 0.547 | -1.56 (-3.72, 0.59) | 0.154 |
|  | Has other/miscellaneous pets | 6108 | -2.76 (-10.81, 5.29) | 0.502 | $4.27(-1.63,10.18)$ | 0.156 |
| 2 | Vocabulary Score |  |  |  |  |  |
|  | Has any Pet | 6176 | 0.99 (-1.29, 3.28) | 0.395 | -0.02 (-1.80, 1.77) | 0.985 |
|  | Has Dog | 6169 | -0.79 (-3.75, 2.17) | 0.602 | -1.13 (0.33, -3.39) | 0.326 |
|  | Has Cat | 6171 | -0.72 (-3.22, 1.78) | 0.572 | $-1.53(-3.47,0.42)$ | 0.124 |
|  | Has other/miscellaneous pets | 6172 | -2.09 (-9.07, 4.88) | 0.556 | 3.78 (-1.55, 9.13) | 0.164 |
| 2 | Non-Verbal Communication Score |  |  |  |  |  |
|  | Has any Pet | 6150 | 0.22 (0.05, 0.39) | 0.014* | 0.18 (0.04, 0.32) | 0.014* |
|  | Has Dog | 6143 | 0.08 (-0.14, 0.31) | 0.469 | 0.06 (-0.12, 0.24) | 0.524 |
|  | Has Cat | 6145 | 0.02 (-0.17, 0.21) | 0.823 | 0.05 (-0.10, 0.21) | 0.517 |
|  | Has other/miscellaneous pets | 6146 | -0.09 (-0.62, 0.44) | 0.731 | 0.18 (-0.25, 0.60) | 0.420 |


|  |  | Univariable |  |  |  | Multivariable |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | $\mathrm{B}(95 \% \mathrm{CI})$ | $p$ | $\mathrm{~B}(95 \% \mathrm{Cl})$ | $p$ |  |
| $\mathbf{2}$ | Social Development Score |  |  |  |  |  |  |
|  | Has any Pet | 6158 | $0.06(-0.24,0.36)$ | 0.687 | $0.13(-0.09,0.36)$ | 0.270 |  |
|  | Has Dog | 6151 | $-0.41(-0.79,-0.03)$ | $0.035 *$ | $-0.21(-0.49,0.08)$ | 0.159 |  |
|  | Has Cat | 6153 | $-0.03(-0.36,0.29)$ | 0.852 | $-0.03(-0.27,0.22)$ | 0.829 |  |
|  | Has other/miscellaneous pets | 6154 | $0.25(-0.66,1.16)$ | 0.587 | $0.67(-0.01,1.35)$ | 0.053 |  |

Analyses were adjusted for: sex, ethnicity, maternal depression at almost 2 and 4 years, maternal anxiety at ages almost 2 and 4 years, overcrowding at 2 years, house type at ages 2 and 3 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership, birthweight, child has twin, child attended day care at 15 months, and 4 years, number of languages spoken in the home, developmental delay at 18 months, child temperament, older children living in the house, stressful life events at almost 2 and 4 years old and mother-child bonding at age 3 years

Table 38. Univariable and multivariable random effects hierarchical model for pet ownership and RDLS score

|  | Unadjusted <br> estimate | Unadjusted <br> CI | $P$ | Adjusted <br> estimate | Adjusted <br> CI | $P$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| RDLS |  |  |  |  |  |  |
| (intercept) | 40.87 | $39.55,42.20$ |  | 33.98 | -2.12, |  |
|  |  |  |  |  | 70.09 |  |
| No | ref |  |  | ref |  |  |
| Yes | 0.61 | $-1.17,2.38$ | 0.502 | 0.41 | $-2.04,2.86$ | 0.743 |

Analyses were adjusted for: sex, ethnicity, maternal depression at almost 2 and 4 years, maternal anxiety at ages almost 2 and 4 years, overcrowding at 2 years, house type at ages 2 and 3 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership, birthweight, child has twin, child attended day care at 15 months, and 4 years, number of languages spoken in the home, developmental delay at 18 months, child temperament, older children living in the house, stressful life events at almost 2 and 4 years old and motherchild bonding at age 3 years.

Chapter VIII

Discussion

This chapter consists of a summary of the main findings, critically discusses the results and discusses the significance and implications of the key findings of this thesis along with recommendations and areas for future research. Deductions are made on why pets are deemed to be beneficial to human health as portrayed in the media. Lastly, limitations of the dataset and methodological limitations of the chosen analyses are discussed.

### 8.1 Summary of results

This is the first study looking at the association between pet ownership and child development. This project is both novel and original in its approach and findings.

Overall, there were relatively high proportions of PO within ALSPAC. Factors that contributed to the ownership of pets in adolescence were sex, birth order, maternal age, maternal education, number of people in the household, house type, and concurrent ownership of other pets. The direction of association varied according to pet type.

No evidence of an association was found between PO and positive emotional health outcomes in childhood or adolescence. However, isolated associations were found between cat ownership and lower self-perceived scholastic competence at age 8 and PO with a higher odds of social anxiety symptoms at age 7 ( $31 \%$ more likely to be socially anxious). It is important to note that a high number of comparisons were made, and therefore there is a high likelihood that some comparisons reached statistical significance by chance. No evidence of an association was found between PI and emotional health outcomes.

Some evidence of an association was found between PO and behavioural outcomes in childhood. The ownership of cats at age 3 was associated with higher odds of hyperactivity ( $12 \%$ more likely to be hyperactive), and pet, cat and dog ownership was associated with higher odds of conduct disorder in childhood (parents were 14$44 \%$ more likely to rate the child as having conduct disorder. Dog ownership was associated with increased prosocial behaviour score at age 3 (0.24 increase), and ownership of smaller pet types such as rabbits and rodents was associated with a lower
likelihood of peer problems ( $28 \%$ less likely) and fewer total behavioural difficulties (27\% less likely ) at age 11.

No evidence of an association was found between pet ownership and positive cognitive outcomes (increased attention, less impulsivity and better memory) in childhood. Dog ownership was associated with a poorer ability in attentional switching (0.42 increase in score).

PO was associated with poorer educational attainment at KS1, KS2 and GCSE in a variety of subjects, and findings were generally consistent across pet types, however these effects were small. No evidence of an association was found between PI and educational attainment at KS1.

Lastly, owning a pet was associated with a higher language comprehension score at age 5 ( 1.01 increase in score), and a owning a pet at age 2 was found to be associated with a higher non-verbal communication score (0.18 increase in score).

### 8.2 Discussion of results

### 8.2.1 Pet ownership

Pet ownership patterns

The PO patterns in ALSPAC are similar to other research suggesting that marginally higher levels of PO exist in middle childhood (between 8 and 12-years-old) (Kidd \& Kidd, 1985; Melson \& Fogel, 1989; Paul \& Serpell, 1992) compared to infancy and adolescence. In ALSPAC, cat ownership remained reasonably constant from ages 11 to 18 years; small mammal (i.e. rabbits and rodents) ownership decreased and dog ownership increased, consistent with other research (Marsa-Sambola et al., 2016). Dogs overtook cats as the most common pet which is also consistent with other data from UK (Murray et al., 2010; Murray, Gruffydd-Jones, Roberts, \& Browne, 2015; PFMA, 2014; Westgarth et al., 2013; Westgarth et al., 2007). Interestingly, in ALSPAC, dog ownership did not follow a linear trend across childhood; in infancy and young childhood, dog ownership declined, suggesting families were more likely to acquire a dog once the child reaches middle childhood. This supports findings that dogs are more common in households with older children (Westgarth et al., 2007).

Pet ownership predictors in adolescence

This study, consistent with previous findings on childhood in ALSPAC (Westgarth et al., 2010), found similar factors contributing to the ownership of different pet types in adolescence.

Among 7-year-old ALSPAC children, owning one type of small pet was commonly associated with owning another type. However, no evidence was found for
an association between dog ownership and cat ownership, similar to data from earlier childhood (Westgarth et al., 2010). This is consistent with other null findings on joint cat and dog ownership (Murray et al., 2015), but is at odds with studies in the UK and Ireland that do find associations (Downes et al., 2009; Murray et al., 2010; Westgarth et al., 2010b). Dog ownership among ALSPAC children at age 13 years reflected the findings from 7 years (Westgarth et al., 2010) in terms of association with concurrent bird, horse and fish ownership. Care is needed in interpretation; it may instead be that owning a dog is a causal predictor for owning a horse, bird or fish (or vice versa), or these relationships could be fully or partly due to other characteristics e.g. the same factors that lead someone to own a dog make them more likely to own a horse, bird or fish.

## Parental education

In contrast to findings at 7 years, there was no relationship between cat or dog ownership and education level of the mother or the father at age 13. This also contrasts with other studies which showed that cat owners had higher (Murray et al., 2010) or lower (Eller et al., 2008) education levels than those without cats, and that dog ownership decreased among owners with increasing educational attainment (Downes et al., 2009; Eller et al., 2008; Murray et al., 2010). According to other research, adolescents were more likely to report having pet dogs if their parents were employed (Marsa-Sambola et al., 2016), or had lower social class (Downes et al., 2009) or family affluence (Marsa-Sambola et al., 2016). Those with a medium family affluence level were less likely to own a cat than those with a low family affluence level (MarsaSambola et al., 2016). The present study did not find any association between dog ownership and paternal or maternal social class at adolescence, as it had for childhood
(Westgarth et al., 2010). Meanwhile rabbit, rodent and bird ownership models at age 13 identified similar associations with education and social class as those obtained at age 7. Likelihood of owning a bird decreased with higher maternal education, and was highest in skilled manual, and part-skilled paternal occupations at both ages. In a previous study, adolescents were also less likely to own birds if their family had a medium or higher family affluence level than adolescents with low family affluence level (Marsa-Sambola et al., 2016).

Previous maternal pet ownership
Previous studies have shown a relationship between current and later PO (Paul \& Serpell, 1993; Poresky, Hendrix, Mosier, \& Samuelson, 1988b). At age 7 years, bird ownership was the only pet type not affected by whether the mother owned pets as a child; this changed at age 13 years, where both dog ownership and horse ownership were also not affected by whether the mother owned pets as a child. Horse ownership at age 13 cannot be compared to ownership at age 7 years, as it was not measured on previous occasions. The finding that, at adolescence, dog ownership was not explained by mothers' previous PO could be due to greater participation of the adolescent in the decision to obtain a pet, thus reducing the influence of maternal PO history. However, for horse ownership, it can be argued that financial considerations may depend on the parent, and therefore the decision to obtain a horse is likely more complex. At age 13 years, maternal PO did predict rabbit ownership, as had been the case at age 7 years. One limitation of our data is that we do not know the individual pet types the mother had owned as a child, and no qualitative data was collected on reasoning to own a particular type of pet, therefore, any interpretation relies on speculation.

Maternal age at delivery
Findings differed slightly between the 7 and 13-year models in terms of the effect of maternal age at delivery on the likelihood of PO. At age 7, maternal age at delivery was independently associated with dog and rabbit ownership, with likelihood of ownership decreasing as maternal age increased. At age 13 years, maternal age at delivery was again inversely associated with the likelihood of dog ownership, whereas it was now positively associated with cat ownership. It could be hypothesised that mothers who have children later have higher career or family demands, and therefore choose to own 'easy to care for' pets such as cats over dogs. Westgarth et al (Westgarth et al., 2010) concluded these associations were not likely due to socio-economic differences between mothers who give birth when they are older or younger, as socioeconomic differences were also included in their model.

Household size
In the present study, the number of people in the household was only positively associated with rodent ownership at age 13. Larger household size has previously been associated with dog ownership in the UK (Murray et al., 2010; Westgarth et al., 2007), and in ALSPAC children at age 7 (Westgarth et al., 2010), but not in other studies (Westgarth et al., 2010b). Previous research also suggests that larger families are more likely to have companion animals (Marsa-Sambola et al., 2016; McHarg, Baldock, Heady, \& Robinson, 1995). Why this differs at adolescence is not clear, but may be due to the difference in sample sizes used for studies with children and adolescents. Research findings regarding PO and numbers of siblings, clearly related to household size, is inconsistent (Covert et al., 1985; Melson, 1988; Paul \& Serpell, 1992; Rost \& Hartmann, 1994; Siegel, 1995; Westgarth et al., 2013).

In addition to family size, birth order may be an explanatory factor. At age 7 years, the presence of an older sibling was an independent predictor of family ownership of dogs, rodents, birds and fish. At age 13 years, there is only evidence of an association between the presence of older siblings and the likelihood of dog or rodent ownership. Other research has suggested that youths with younger siblings own fewer pets than those without younger or any siblings (Paul \& Serpell, 1992). However, the ALSPAC findings are difficult to dissect because, overall dog ownership increases whereas rodent ownership declines across adolescence, and yet their association with having an older sibling is similar.

## Gender

The associations with gender and pet type at age 13 years were identical to the models at age 7 ; females were more likely to own cats, rabbits, and rodents. In addition, females were also more likely to own horses at age 13. These findings are consistent with other studies on cats (Downes et al., 2009; Murray et al., 2010; Westgarth et al., 2013; Westgarth et al., 2010b), rodents and horses (Westgarth et al., 2013); still other studies found no gender differences (Marsa-Sambola et al., 2016; Siegel, 1995; Vidović et al., 1999). It has been suggested that girls may influence their parents to own certain types of pets (Westgarth et al., 2010). In ALSPAC there is difficulty in inferring the influence of gender on family PO, as family structures are likely to have both sexes (Marsa-Sambola et al., 2016; Müllersdorf et al., 2010; Paul \& Serpell, 1992), and more than one attribute of the child and/or the family affects the decision to get a pet.

House type
At age 13 years, house type was only associated with horse ownership, in contrast to models at age 7 years where house type was also associated with both dog and rabbit ownership. Westgarth et al. (2010) suggested this could be explained by family reasoning that dogs and rabbits are perceived to require more outdoor space than other pet types, which could also justify space for horses. Although maternal education and social class were not significant in the final model, socio-economic status (SES) should not be discarded as a potential influence for horse ownership as house type is a measure of SES.

## Ethnicity

At age 7 years, ethnicity other than 'white' was associated with a lower likelihood of owning a cat or rodent (Westgarth et al., 2010). However, at age 13 years, ethnicity was not related to ownership of any type of pet. Other research finds ethnicity to be the single most important predictor of PO , with white adolescents being more likely to own any types of pets than non-white adolescents (Mixed, Asian, Black, and adolescents from other ethnicities) (Marsa-Sambola et al., 2016). This is supported by other studies in adolescents (Siegel, 1995) and young adults (Brown, 2003). The lack of association in the ALSPAC cohort at age 13 years may be due to insufficient power. In the ALSPAC dataset the prevalence of ethnic minorities is relatively low (Boyd et al., 2013).

Table 39. Table summarising predictors for each pet type

,+- and x indicate if the relationship positive, negative or null.

### 8.2.2 Emotional health

This study provided no evidence of an association between PO and positive emotional health outcomes in childhood or adolescence. There were no consistent patterns according to the child's age, and no evidence for differential associations by pet type. This is at odds with a common belief that pets have a beneficial effect on emotional health in CYP, formulated on the basis of results from other cross-sectional and qualitative studies (Purewal et al., 2017) (see chapter 3). On the other hand, our results support those of a recent study using a longitudinal design (Miles et al., 2017); this propensity-score-weighted population-based study established that any benefits of owning pets on psychological health in children and adolescents were largely explained by confounding factors (Miles et al., 2017). Their results also suggest that confounding factors such as socio-economic status are more important predictors of emotional health in CYP. The link between childhood poverty and mental health problems is commonly known (Ayre, 2016; von Rueden, Gosch, Rajmil, Bisegger, \& Ravens-Sieberer, 2006) and has previously been found in this dataset (Joinson, Kounali, \& Lewis, 2017). Specifically, major financial problems, parental social class and maternal mental health, education and age at delivery were the strongest predictors of child and adolescent emotional health in our cohort, and also have been shown to predict PO in this cohort (Purewal et al., 2019; Westgarth et al., 2010). Therefore, as we have done in the present study, it is important to take socio-economic factors into account in future HAI studies investigating the impact of pets on human psychological health.

Self-esteem

The association we found between cat ownership and lower self-perceived scholastic competence was unexpected and could be due to residual confounding. Cat owners have been found to be more neurotic than dog owners (Gosling, Gosling, Sandy, \& Pottert, 2010), and are often reported to have a higher socio-economic status (Lyman \& Luthar, 2014; Murray et al., 2010), which may be linked to perfectionist personality traits (Krstic \& Kevereski, 2015) in themselves or their parents, and that could partly explain why children who own cats have lower self-confidence in their academic work. This explanation is plausible but highly speculative, and not easily tested with our data. Moreover, because self-esteem in the ALSPAC cohort was only measured once at age 8 years, we relied on cross-sectional data and therefore cannot determine the direction of the association. Alternatively, anxious people in this regard may be more likely to get 'easy to care for' pets such as cats for themselves or for their children.

Despite a large body of research finding that pets positively affect self-esteem (Purewal et al., 2017), we found no association between PO and children's global selfworth. However, the SPPC subscale 'global self-worth' has previously been criticized as unreliable in children younger than seven years of age (Harter, 1985), due to the child's inability to separate their true selves from their ideal selves. As 8 -year-old children are unlikely to largely differ in self-reflection to children under seven, it could be argued that effects were missed in the present study. In addition, children have a tendency to deny experiencing problems or to underestimate their severity in selfreports (Cox, Morris, Borowitz, \& Sutphen, 2002). On the other hand, although our findings should be interpreted in light of these limitations, they do fit the broader pattern of null results at ages 7-13.

## Anxiety

Despite some theoretical plausibility (McNicholas \& Collis, 2000, 2001) we find no associations between owning pet dogs and separation anxiety symptoms, nor generalised anxiety. This is consistent with previous research (Gadomski et al., 2015; Vidović et al., 1999).

It is unclear why 'any' and 'other' PO was associated with a higher odds of social anxiety symptoms at age 7 (but not ages 10 and 13). One explanation could be that families of children with social anxiety symptoms acquired pets to support the children. However, our PO history analyses suggest this may not be the case; anxiety outcomes did not differ between children who sometimes and always owned pets, in comparison to those who had never owned pets. Alternatively, a prospective study of children aged 8-12 years (Paul \& Serpell, 1996) found PO to be partly detrimental to levels of children's social interaction; attachment to pets at the 12 month follow up was associated with both increases in the amount of time spent alone, and decreases in children's time spent with family and friends ( $\mathrm{P}<0.05$ ), which in turn may influence social anxiety. Furthermore, evidence has suggested that the child-pet bond may have negative psychosocial implications for children if the pet is the child's sole source of emotional support (Bryant, 1985; Guerney, 1991). However, our association did not remain in a repeated measures model accounting for ages 7, 10 and 13 years. It could also be considered that the 'other' category is relatively vague; for both 'any' and 'other' pet ownership, findings could be spurious. It is possible that findings with 'other' pet could be driven by the ownership of 'any' pets.

## Depression

Despite previous research findings that PO may protect adolescents against depressive symptoms (Rhoades et al., 2015), no evidence of associations were found. This supports a school-based study in which pets had no effect on self-reported emotional health or well-being in adolescents (Mathers et al., 2010), and other findings in younger children (Gadomski et al., 2015).

Summary

Our findings lead to the overall conclusion that PO is not associated with emotional health outcomes in childhood or adolescence, at least in the ALSPAC cohort. Pets may only act as a source of comfort and emotional support if they are a twinship self-object to the child (Brown, 2007), and more research is needed to understand these relationships. Previous research suggests that animals make better twinship self-objects than humans, due to their inability to disagree with the human's interpretation of how he or she feels (Brown, 2007), and thus leaving more room for the projection of the human's emotions. Other interpretations are possible. The buffering hypothesis (Cohen \& Wills, 1985) may also help explain our null findingssocial support and emotional benefits of PO may only come into play for individuals experiencing adverse or stressful events. Population-based studies are not well suited to detect such effects (Miles et al., 2017). Finally, it is important to recognize that, at least in some instances, animal caregiving may elicit negative emotions related to pet care, health, and separations (Archer, 1997; Luhmann \& Kalitzki, 2016); strong attachment to pets has also been associated with emotional distress and depressive symptoms (Islam, 2013; Peacock, Chur-Hansen, \& Winefield, 2012).

### 8.2.3 Behaviour

This study provided some evidence of an association between PO and positive behavioural outcomes in childhood. Overall patterns indicated that dog ownership was positively associated with conduct disorder in both childhood and preadolescence, but also suggested that different pet types may benefit different age groups e.g. dog ownership was associated with prosocial behaviour at age 3, and ownership of smaller pet types such as rabbits and rodents was associated with fewer peer problems and fewer total behavioural difficulties at age 11. The literature review (see chapter 3) concludes that the current evidence of the impact of PO on child behavioural outcomes is inconsistent. These results may explain why; the impact from ownership of different pet types is likely to differ depending on each behavioural outcome and child age.

## Emotional difficulties

At ages 3 and 11 there was no evidence of an association between PO and the likelihood of emotional health difficulties, which supports the findings of the previous emotional health analyses in the present study using the DAWBA and MFQ. This is likely due to similar questions being asked in the RRS and SDQ emotional difficulties subscales e.g. Child appears miserable, unhappy, tearful or distressed. This provides further consistent evidence that pets are unlikely to have a beneficial impact on emotional health in youths. Similarly, an American study of children in a paediatric primary care setting found no differences in the behaviour of dog owning children and non-dog owners aged 4-10 years measured by the SDQ (Gadomski et al., 2015). Again, no effects of PO were found in children aged 13-18-years on social functioning
and psychosocial health summary scores (Mathers et al., 2010) measured by the Paediatric Quality of Life Inventory.

Hyperactivity

The ownership of cats at age 3 was associated with increased odds of hyperactivity. Children with ADHD are more likely to own pets (Miles et al., 2017), and there is evidence that dog interaction with children diagnosed with ADHD is more likely to have an excitatory effect than a calming one (Somervill, Swanson, Robertson, Arnett, \& MacLin, 2009), however we do not see the same effect here with pet dogs. If cat owners (and cat owning families) are more likely to be neurotic (Gosling et al., 2010) than dog owners, perhaps it is plausible to suggest this may present itself as hyperactive behaviour, or affect the way parents address this behaviour in their children. However, more likely, this is a chance finding, as hyperactive behaviour is more common in younger than in older children, and cats were the most common pet in ALSPAC. Alternatively, a relatively recent study also investigated the associations between PO on SDQ outcomes in 10 year old children using two German birth cohorts, and found a similar increased likelihood of hyperactivity/inattention (Casas et al., 2013), however they attributed this finding to the exposure of increased microbial contact such as mould and dampness caused by indoor pets. Interestingly, the authors state this exposure to indoor microbial agents can affect cognitive function, and speculated this can cause behavioural problems. As this data was available in ALSPAC, we were able to control for housing defects and associations did not attenuate.

## Conduct Disorder

The Casas et al. (2013) birth cohort study also provides further support for our findings where PO was positively associated with conduct disorder. Casas et al. (2013) yet again explained the association between PO and increased likelihood of conduct disorder by the exposure to indoor microbes, which can affect cognitive function. Our alternative explanations include families acquiring pets to help calm, tire or entertain unruly children, or confounding between PO and larger households (seen in ALSPAC for dog ownership (see chapter 5)); larger, and more crowded households are related to poor behaviour and children from large families are twice as likely to develop conduct disorder and become delinquent than children from smaller families (British Medical Association, 2013). This is likely due to less parental supervision and more sibling aggression, all of which may contribute to behaviour problems. In addition, dogs can be high-energy animals, which may feed into and maintain conduct disorder behaviours, however this does not provide an explanation for why we also see this in cats.

Prosocial behaviour

Owning 'other/miscellaneous' pets at age 3 was associated with lower likelihood of experiencing prosocial difficulties, and dog ownership at age 3 was also associated with increased prosocial behaviours (kind to others, kind to animals, considerate of other's feelings, shares toys,) when measured on a continuous scale. Other studies have found similar effects in comparable aged children (3-6 year olds) (Poresky \& Hendrix, 1989; Vidović et al., 1999). Research in adults (Colarelli, McDonald, Christensen, \& Honts, 2017) also found the presence of companion dogs to increase prosocial behaviour (increased verbal cohesion, physical intimacy and higher ratings of
trustworthiness) in work and educational settings. It would be interesting to extend this research to children within educational settings. The presence of guinea pigs in the classroom has been shown to increase social functioning and social skills (O'Haire et al., 2013), however there is a difference between animal presence and PO. Other research concludes that young children derive similar developmental benefits (social competence and empathy) from interactions with companion animals (Poresky \& Hendrix, 1989). Bonding with pets appeared to be a stronger determinant of these associations than PO, which may explain why we see this effect in younger children only, who are likely to be more attached to their pet (Bodsworth \& Coleman, 2001) whilst older children become more interested in peers (Coleman, 2011; MarsaSambola et al., 2016; Mathers et al., 2010). However, a different study showed no evidence of an impact of dog ownership on similar prosocial outcomes (Social Externalizing outcomes) such as sharing and fighting behaviour and understanding the feelings of others in a wide age range of children (4-10 years) (Gadomski et al., 2015).

Parental input contributes to the early development of prosocial behaviour by eliciting conversation about others and own emotional states to teach children (Brownell, Iesue, Nichols, \& Svetlova, 2013). In addition, children learn prosocial behaviours from adults through imitation and collaborative interactions (Waugh, Brownell, \& Pollock, 2015). Pets may be indirectly increasing young children's prosocial behaviour through acting as a point of conversation between adults, peers and children (O'Haire et al., 2013; Poresky, 1996), or by adults teaching children how to correctly care for animals (Maruyama, 2011).

Patterns in ownership of small pet types (across all behaviour outcomes)
Ownership of smaller pet types such as rabbits and rodents was associated with fewer peer problems and less total behavioural difficulties at age 11. Hirschenhauser, Meichel, Schmalzer, and Beetz (2017) speculated that young children develop highquality relationships with pets, particularly those that are taxonomically closely related, such as dogs and cats, but less so with other pet species, such as birds or fish, however older children were also able to strongly attach to other pet species. They concluded that mental relationship representations change during puberty and that older (11- to 14-year-old) children may no longer make attachments to pets based on them being behaviourally similar to people which could explain why we do not see associations between owning small/other pet types and behavioural difficulties at age 3. Smaller pet types (other than cats and dogs) may have positive influences on behavioural difficulties at age 11 due to not only providing companionship but also the opportunity for children to assume more responsibility in pet care. Arguably, smaller pet types require a lot of manual care in comparison to cats and dogs e.g. cage cleaning, feeding, and handling, which is usually accounted for by the child. Older children are more likely to be able to take care of the pet, and plenty of research has demonstrated the link between pet care and responsibility, and autonomy (Black, 2012; Endenburg \& van Lith, 2011; Mueller, 2014; Rew, 2000; Van Houtte \& Jarvis, 1995). Pet care is an activity which can contribute to the honing of executive functions (Freund et al., 2016) that underlie planning, attention, memory and self-control (Boyer, 2014; Ling et al., 2016). Pet care may in turn increase good behaviour, explaining our findings that ownership of smaller pet types such as rabbits and rodents was associated with fewer peer problems and less total behavioural difficulties at age 11.

Alternatively, the ownership of smaller pets is more common in smaller households (see Chapter 5), in which children suffer less from behavioural issues (British Medical Association, 2013), however household size was accounted for in the ALSPAC models.

Summary

Our findings lead to the overall conclusion that children who own pets may be more likely to have hyperactivity and conduct disorders, however PO may also increase prosocial behaviour in younger children. Furthermore, small pet types such as rabbits or rodents were associated with fewer overall behavioural difficulties in older children. Therefore, within the ALSPAC cohort, the effects of PO on behaviour differ by pet type, age of the child, and the outcome in question.

### 8.2.4 Cognition

This study addresses an important research gap, highlighted in the literature review (see Chapter 3), regarding the possible impacts pets may have on cognitive development, and specifically executive function. In our study, no evidence of an association was found between PO and positive cognitive outcomes (attention, impulsivity and memory) in childhood.

Findings are supported by previous research that found no differences in Attention scores (Paediatric Symptom Checklist 17) when comparing dog-owning children to non-dog owners aged 4-10 years (Gadomski et al., 2015). Despite previous research findings where animal presence has positive effects on memory and attention (Gee, Crist, et al., 2010; Gee et al., 2015; Gee et al., 2009), these effects do not seem to apply to PO. This is likely due to the proximity of the animal, which elicits immediate biological responses, and in turn affects executive function (see chapter 2). The dopamine release from an interaction with a dog (Odendaal \& Meintjes, 2003), which is known to enhance concentration and attention (Genro et al., 2010), will not have been present in ALSPAC children who completed the task in CiF clinics. If such close temporal links are needed to see effects of dog interaction on executive functions, it can be hypothesised that it is not the long-term presence of a pet, but instead the current proximity of an animal, which may exert such cognitive benefits. However, it can be argued that the current evidence is not strong enough yet to support this hypothesis.

Unpredictably, dog ownership was associated with a poorer ability in attentional switching. Attentional switching or 'cognitive flexibility' is arguably the most complex EF as it both requires and builds on inhibition and working memory
(Davidson, Amso, Anderson, \& Diamond, 2006). One possible explanation for this result could be that families may acquire dogs to support children with developmental disabilities (or at least, symptoms of disabilities), therefore poorer performance in attentional switching in dog owners would be expected, as seen in ADHD (Cepeda, Cepeda, \& Kramer, 2000) and Autism Spectrum Disorder (ASD) (Yerys et al., 2009). However there is little evidence of developmental disabilities and/or delay in ALSPAC, therefore spurious findings may be a more plausible explanation.

Personality traits may also play a role; dog owners are more likely to be extroverted (Gosling et al., 2010). Research shows that the Anterior Cingulate Cortex (ACC) of the brain, which plays a role in cognitive control and decision making, may contribute to personality traits such as extroversion (or vice versa), which has been associated with worse performance in task switching (Umemoto \& Holroyd, 2016). As there is no measure of personality within ALSPAC, this remains a speculation. Summary

Our findings lead to the overall conclusion that, in ALSPAC, childhood PO is not associated with positive cognitive developmental outcomes. Dog ownership was associated with a poorer ability in attentional switching; further research is needed to determine whether or not this was a chance finding, and not due to lack of proximity effects or personality differences.

### 8.2.5 Education

This was the first study to assess whether PO in childhood and adolescence is associated with educational attainment. PO was consistently associated with poorer educational attainment at KS1, KS2 and GCSE in a variety of subjects, and findings were generally consistent across pet types.

It is difficult to dissect why these associations exist in the ALSPAC dataset. At KS1 (age 7), ownership of all pet types except cats was associated with poorer educational attainment. As cat ownership was associated with a higher socioeconomic status and older maternal age at delivery (see chapter 5), and dog ownership was associated with a younger maternal age at delivery (see chapter 5), this could provide some clarification in the form of residual confounding (although analyses were adjusted for these variables). Younger mothers tend to have lower socioeconomic status, less schooling, and less stable partnerships than older mothers (Fall et al., 2015), and therefore may provide less support with education. In addition, it can be argued that exam tests require a fair amount of attentional switching (i.e. from one question to the next), and as dog ownership was associated with a poorer dual task performance (see cognition section above), this could partly explain these results.

However, ownership of all pet types, including cats, was also associated with poorer KS2 (age 11) SAT scores and some poorer GCSE (age 15) outcomes. It could be hypothesized that as the child gets older, educational success becomes the child's own responsibility rather than the parents'. Here, it is possible that families obtain pets to support children with developmental difficulties, which would explain the lower grades. This could also provide an explanation for the finding that always owning pets up to age 15 was associated with poorer GCSE attainment in English and Maths. To
investigate this further, data was requested for Special Needs Status (SNS) in ALSPAC. However, the data could not be used due to small percentages of children meeting SNS criteria, and therefore even smaller numbers with complete PO and educational data.

It is possible that the association between PO and poorer educational attainment is attributable to an unknown confounding factor. In an attempt to explore this further, the models were also adjusted for additional variables including parental marital status, maternal smoking, financial difficulties, dog walking, time spent watching TV, time spent outdoors and time spent doing homework (see Chapter 4). However, these variables were discarded from the final models, as they did not affect the outcome.

No evidence was found in ALSPAC supporting previous research that pet owners may be better at biological subjects (Geerdts et al., 2015; Prokop et al., 2008). Interestingly, the finding that cat ownership was not associated with a poorer attainment in English at both KS2 and GCSE, like other pet types were, is at least partly in line with survey data that finds cat owners to be more creative than dog owners, and to enjoy reading and writing practices (Mars Petcare, 2017). However, this evidence stems from a market research survey, and is therefore based on opinion rather than the use of standardized measures, so the results must be considered with caution.

In summary, PO is consistently associated with lower educational attainment in a number of different subject and ages, despite adjustment for logical confounders.

### 8.2.6 Language development

This was the first study to look at the association between PO and validated language outcomes in childhood. Some interesting findings were observed for comprehension and non-verbal communication.

Currently owning a pet was associated with a higher comprehension score at age 5 (RDLS). This supports previous suggestions that owning pets may facilitate language acquisition, with the pet acting as subject of conversation, to stimulate communication, and build vocabulary (Poresky, 1996). In further support, in the same age group, bonding with a pet was found to enhance verbal intelligence scores (Poresky \& Hendrix, 1989) (see Chapter 3). Similar positive influences from the presence of animals (but not pets) has been found in studies on language, literacy, and reading ability (Hall et al., 2016; le Roux et al., 2014; O'Haire et al., 2013) (see Chapter 3). This study provides partial evidence that such positive influences may be extended to pets in the home.

However, this positive association in comprehension was not present in children aged 2 years, and did not remain significant in a repeated measures design accounting for scores at both time points. This can be attributed to Vygotskian theory; although children aged 2 years are able to use Social speech, they are not yet able to use Private Speech (see Chapter 2). Private speech can enhance thought processes such as planning, concept formation and comprehension (Vygotsky, 1987). Children raised in environments characterized by low verbal and social exchanges exhibit delays in private speech development (Vygotsky, 1987), therefore it could be hypothesized that pets provided verbal and social stimulation in ALSPAC children, leading to earlier
private speech development and better language comprehension. It would be interesting to investigate further whether PO enhances language practice; both social speech and private speech (which enables better comprehension) improve through practice. Alternatively, explanation can be provided for by EMC theory where language acquisition is said to arise from multiple factors such as cognitive constraints, social-pragmatic factors, and global attentional mechanisms (Hirsh-Pasek et al., 2004; Hollich et al., 2000). It could be that the child at age 5 is able to interact with the pet more than a child aged 2 years, and therefore has a wider access to the multiple cues pets may give (see Chapter 2) to aid in language development.

No associations were found between PO and vocabulary, social development and total communication score at age 2; therefore, it could be suggested that effects are unlikely to be seen in younger children. Unfortunately, similar outcomes were not measured in older children within ALSPAC. Further research is needed to understand whether PO can enhance other aspects of language e.g. semantics, pragmatics or syntactic development.

However, it seems pets may be able to enhance other types of communication at younger ages. Interestingly, owning a pet at age 2 was associated with higher nonverbal communication scores. Non-verbal communication includes eye gaze, vocalizations, and prelinguistic gestures (Trevarthen, 1978). It is plausible that children who own pets are better practised in such body language and communication, to enable them to interact with the pet, or with parents/siblings to communicate about the pet as an object of interest. Pet interaction therefore may enhance social cues such as eye gaze, pointing, and speaker intention, needed for language development through usage-based language acquisition theory (Brooks \& Meltzoff, 2008).

In summary, PO is associated with higher comprehension at age 5, and higher non-verbal communication score at age 2 . Interaction with, and talking about household pets are likely to provide children with opportunities to exercise thought processes and verbal stimulation. These findings are likely to reflect the age-related ability of the child within language development.

### 8.2.7 Overall patterns

Overall, no clear patterns across outcomes, pet types or child age were found in the ALSPAC dataset. PO does not appear to have any beneficial impact on emotional, cognitive or educational development of children. They may however, have a positive impact on social development as seen through some aspects of language development and prosocial behaviour. What follows are attempts to explain the broader pattern of results.

## Sociability function

It seems, at least in ALSPAC, that pets may have a sociability function. They may act as social catalysts by being social lubricants between family or peers as we see in adults (McNicholas \& Collis, 2000; Wood et al., 2017) (see chapter 2), and possibly as surrogates where children lack human companionship (Veevers, 1985) to aid language and prosocial development. The relationships children have with their pets may at least in part meet the optimal conditions required by parenting for developing prosocial behaviour (Carr, 2015; Turiel, Smetana, \& Killen, 2014): 1) promoting secure attachment through empathy, 2) being warm and nurturing, 3) offering unconditional approval, 4) positive responses to child's requests, 5) clear rules (and praise/punishment) for behaviour. Interactions with pets may provide some of these conditions, i.e. 1-3. Interestingly, if not met, these conditions can contribute to the development of conduct problems (Carr, 2015). However, in ALSPAC pets and dogs were associated with both prosocial behaviour and poorer conduct. Thus, it is likely that pets do not provide all of the optimal conditions to prevent conduct problems; the relationships children have with their pets differ from relationships with parents. This is fitting with other literature that suggests the relationships we have with
our pets are unique and not a replacement for people (Charles \& Davies, 2011; Cohen, 2002; Westgarth, Christley, Marvin, \& Perkins, In Press).

## Emotional expression

Recent research from a longitudinal study in Japan found that children who had a pet at home in toddlerhood had a lower prevalence of poor emotional expression ('Does your child have difficulty in expressing their emotions well?'), compared to those without pet (Sato, Fujiwara, Kino, Nawa, \& Kawachi, 2019). Our findings in emotional and behavioural development- where PO is associated with poorer social anxiety, increased hyperactivity and conduct disorder- could be explained by high emotional expression, where children express high levels of emotions such as sadness, anger, fear and joy. Further research is needed to determine if and how pets enable children to display 'emotional expression' using validated outcome measures. Although the authors argue that poor emotional expression is a negative trait in terms of not being able to recognise their own emotions or communicate their feelings with others; we suggest that instead it may indicate higher ability to regulate (control) emotions.

Intelligence and learning

Cattell distinguished between two types of intelligence; crystallized and fluid intelligence (Cattell, 1963). Fluid intelligence includes cognitive abilities such as attention, short-term memory and reasoning- all of which are independent of previously existing knowledge and therefore depend less on experience. Crystallized intelligence includes vocabulary, and experiential evaluation which are dependent on experience. Pets, as opposed to therapy or classroom animals, may be able to enhance crystallized intelligence only, explaining the present positive results in language but
not cognitive or academic outcomes. Furthermore, there are different types of learning: statistical learning, learning by imitation, learning by analogy and causal learning (Goswami, 2015). It is possible that pets only aid certain types of learning e.g. learning by imitation and causal learning to enhance language and social development, or other aspects of crystallized intelligence. This is an area for future research.

Gee et al. (2017) devised a model of how HAI activities can impact learning, which shows that HAI indirectly affects learning by affecting or enhancing children's motivation, engagement, aspects of EFs and social interaction. We only see partial support for this model, in which pets may increase social interaction; this suggests there are differences between PO and animal assisted interventions (AAI). Perhaps a clear explanation as to why differences exist between PO and AAI lies in the need for the animal to be present or in close proximity in order to induce hormonal effects.

Discrepancies with qualitative research

The present findings are inconsistent with qualitative research in the field, which tends to suggest positive effects of pets on child development, particularly in emotional health (Purewal et al., 2017) (see chapter 3). Strengths of the ALSPAC dataset (see chapter 4) such as the ability to adjust for confounding factors which pertinently attenuated effects in some models, and support from other well designed longitudinal studies (Miles et al., 2017) may mean that these findings are inaccurate, People may perceive or believe that pets enhance health and development rather than this being the case in reality. This points to evidence that the 'pet effect' may not exist as we know it, in line with suggestions that 'the postulated effects of pets on human mental and physical health is at present not a fact but an unsubstantiated hypothesis' (Herzog, 2011).

Alternatively, the lack of positive findings could be attributed to limitations of the ALSPAC dataset or other study limitations outlined below.

### 8.2.9 Pet Interaction

In a limited number of analyses (emotional health at age 7, and KS1 attainment), it was possible to explore whether associations differed according to pet interaction (child looks after pet in home).

Overall, there was no evidence of an association between pet interaction and emotional health; looking after pets appeared to exert no benefit. However, as the pet interaction question for child involvement was parent reported, it can be argued that the variable is a 'loose' measure of child involvement, which would explain the lack of a clear pattern within emotional health. Although no benefits were seen for pet interaction, the original sample analyses where owning any and other pets was associated with higher odds of social anxiety at age 7, do not seem to hold. However, it could be suggested if pet interaction provided a protective effect for social anxiety, children who did not look after pets should also have higher odds of social anxiety, but that is not the case therefore no such conclusion can be drawn.

There was also no evidence of an association between pet interaction and educational attainment at KS1, suggesting interacting with a pet may not exert any benefits for children regarding exam score.

The lack of findings seen could be due to limitations of the pet interaction variable within ALSPAC. The question was only asked at one time point, allowing only cross-sectional analyses. In addition, there is no parallel PO variable at age 6 in ALSPAC; pet ownership was not asked about at this time point therefore PO at age 7 was used perhaps resulting in some inaccuracy. This means we do not truly know if
the children in the sample owned pets or not. A small number of children stating interacting with pets despite not owning any.

### 8.3 Limitations

This study has some limitations. Chapter 4 outlined limitations specific to the ALSPAC dataset, some of which are revisited here in relation to our findings.

Pet ownership during adolescence

First, the accuracy of retrospective recall of PO could be questioned. However, recall accuracy has been tested for age 7 , when it was compared to data provided prospectively by caregivers on previous occasions. A high level of recall accuracy has been reported between caregiver-reported (at the time) and youth-recalled (later) PO in ALSPAC ( $P$ < 0.0001) (Westgarth, Ness, Mattocks, \& Christley, 2017). Secondly, there may be other confounding variables that were not considered. Other potential confounders could be considered, for example measures of family adversity. Lastly, a large difference in sample sizes between ages 13 and 7, even after multiple imputation, made direct comparison of samples challenging because observed differences could result from sample attrition or non-response, rather than age (nonrespondents in ALSPAC are likely to differ in terms of socio-economic status (Boyd et al., 2013)).

Developmental outcomes

One possibility for why beneficial impacts of PO were not found in the majority of outcomes is that we did not measure the child's relationship with or 'attachment' to their pets using a valid measure (see Chapter 4, Limitations of ALSPAC), and it is precisely this relationship that may be most salient in conferring
psychological benefits, rather than PO. The relationships people have with their pets varies, likely depending on whether they or other family members are the primary 'owner', the duration of PO, the number of pets in their home, their attitude to pets as family members, if the pets live mainly outside, and if they are personally involved in caring duties. As child involvement in dog walking has been associated with the strength and type of relationship with the dog (Westgarth et al., 2013), Dog Walking (Number of times in typical week respondent walked or jogged with household $\operatorname{dog}(\mathrm{s})$ ) was used as a substitute confounder for pet attachment in all models; however our findings still did not differ from when dog walking was not adjusted for (results not shown). At age 6, we were able to look at a limited number of associations between pet interaction and developmental outcomes, however limitations of this variable means the analyses are not as reliable or rigorous as needed.

Another weakness of the study is that the small numbers of children who met DSM-IV criteria for both anxiety disorders and depression meant that our statistical analysis compared children on the derived rate of symptoms of emotional disorders as dichotomous outcome variables instead of DAWBA diagnoses, resulting in a potential loss of variability due to only the children with the most 'severe' symptoms (children who were reported to have suffered from the symptoms the most often, or a lot more than others of the same age) being included in the group with emotional problems (Joinson et al., 2016). Previous cross-sectional studies finding significant associations used samples with higher prevalence rates of emotional health disorder diagnoses, which could explain our largely null findings (Gadomski et al., 2015).

Lastly it could be argued that our analytical approach was too simple. We may have missed positive effects of PO by investigating changes at the population level, not the individual (i.e. acquisition or loss of a pet). In addition, as the emotional,
behavioural and cognitive development of young people is a dynamic process, variables are not independent of, but influence each other. There are complexities when examining such health outcomes; it is difficult to tease apart associations. For example, poor self-esteem may lead to depression and vice versa. Likewise, if families of children with mental, behavioural or cognitive health problems were more likely to get a pet to alleviate symptoms, then one could expect worse, not better, mental health and cognition in children with pets - which fits our results to some extent (although ALSPAC is generally healthy population sample). This could not be clarified in ALSPAC, as although we could see when the pet was acquired, we could not determine the onset of the child's health problem. In addition, most mental or emotional health problems peak at later age points; there is a low prevalence at the ages (<13 years) ALSPAC have collected data for. Theoretical frameworks, such as relational developmental systems theory (RDST) (Mueller, 2014; Overton, 2013), state that child development should not be studied in isolation, but as the product of bidirectional relationships between the child and his/her environment. Given the dynamic nature of human-animal relationships, this is particularly cogent in this research area; the quality of the child-pet relationship may vary based on the developmental period of both the human and pet and the family circumstances involved in the interaction, as well as the duration and intensity of that relationship (Mueller, 2014). An approach such as structural equation modelling may be required in future studies to shed more light on these complex relationships. In addition, shared informant bias could have been considered; at different time points we relied on either mother or the child to report on family's PO and/or child's emotional health. Ideally, additional data from reporters such as teacher or paternal reports would reduce single-informant bias, which is
important when assessing emotional health outcomes (Achenbach, McConaughy, \& Howell, 1987).

## Reflection of methods

Using ALSPAC data to answer the research aims provided a strong research design. Birth cohort studies are rarely used within the field of HAI and can overcome limitations in current research designs e.g. small sample sizes, the availability of multiple detailed outcome variables and confounding factors. Pet ownership data is infrequently included in birth cohort studies (although occasionally recorded to investigate the development of asthma or allergy) due to time and space requirements. In addition, it is probable that researchers do not see the value of including pet ownership data in cohort studies. Analysing this data within ALSPAC for the current project has answered novel research questions in a cost-effective and logistically feasible manner.

However the use of observational methods presents us with many criticisms to reflect on. One important criticism which limits the interpretation of results is the inability to infer causality; looking at associations simply allows the examination of the strength of relationship between variables. These relationships are likely to be bidirectional.

There are potential alternative approaches for future research. One such approach is to improve the quality of observational study design through collecting new data within a smaller scale cohort. Developmental or health outcomes could be assessed both before and after the acquisition of a pet, resulting in a pre-post study design. This would be a costly approach, however the survey data could be tailored towards the research questions, for example pet attachment measures, and reasons for acquiring a pet could be included. However, within a pre-post study design, the selection of a
comparison group may be difficult. In addition, this study design does not address selection bias where people who choose to own pets may differ to people who do not. To address selection bias, an RCT would need to be implemented, which given the topic area, would be unethical as it would require giving out pets to families.

It could be predicted that the perceived health impact of pet ownership could in fact be a placebo effect. The resulting response bias from the placebo effect can affect the internal validity of studies, and is challenging to test out and interpret. Future studies should be careful to interpret findings in relation to this. Alternatively, more creative approaches are needed, such as using control groups of people who might want to own a pet.

Mixed method approach: This project takes a solely quantitative approach. The addition of qualitative approaches to data collection such as carrying out interviews and focus groups would enhance the current project by providing richer data. Data analysis by grounded theory or thematic analysis would provide more insight into how people perceive pets to affect developmental outcomes in childhood.

### 8.4 Recommendations for further research

Pet attachment

In light of these limitations, further research can be proposed. The main concern is the lack of a pet attachment/bonding measure; future research should incorporate this into well-designed longitudinal research. However developing and refining age-appropriate measures for child-animal interaction research, which are both reliable and valid, also remains a priority (Hawkins \& Williams, 2017). A possible barrier to including such measures in cohort studies is the length of the scales.

However, short robust attachment measures, such as the Short Attachment to Pets Scale (SAPS) for children and young people (Marso Sambola et al., 2015), have been validated and could be incorporated in future cohort studies.

Social/psychological characteristics

There needs to be further examination into the social and psychological characteristics of children who are more likely to own pets. For example, if extroverted children (or more extroverted parents of children) are more likely to own pets, this could explain some of our behavioural findings, instead of assuming pets themselves may be directly encouraging or stimulating playful/energetic behaviour. These characteristics also need to be looked at in parents, who are likely to obtain pets for their children.

Proximity effects and study design

Within behavioural, cognitive and perhaps emotional development, it may be that animals need to be present at the time of task/activity to see beneficial effects, which could explain the discrepancy between experimental research and PO studies. Future research should investigate this distinction and the processes behind why effects are seen or not, which is likely due to proximity and short-term biological effects (see chapter 2). Arguably, language and prosocial development relies on processes other than proximal hormonal effects and therefore a different mechanism is at play, which may explain why positive findings were seen in the present study.

Alternative explanation for the differences between experimental and PO studies is that experimental research that involves pet interaction (AAI/AAT studies) is stronger in terms of quality of evidence due to the ability to randomly assign animal conditions to children. This is much more difficult to accomplish within PO research, which is observational.

## Adverse Childhood Experiences (ACEs)

It would be interesting to see if PO or interaction is a protective factor for Adverse Childhood Experiences that have a major and potentially lifelong impact on human health and behaviour in the form of heart disease, type 2 diabetes or drug abuse (Centers for Disease Control and Prevention, 2016b). This was out of the scope of the present study due to time constraints, and the limitation of ALSPAC data being subject to self-selection for PO status.

## Generational differences

It is important to note that ALSPAC started collecting data two decades ago, and generational differences in PO may exist compared to present day. The relationship people have with pets may also have changed during this time. Considering the increasing rates of divorce and family breakdown (ONS, 2017), increased used of social media (O'Keeffe \& Clarke-Pearson, 2011), and possibly reduced tactile contact with others, now is a good time to investigate if, where, and how pets may provide beneficial effects for children.

### 8.5 Conclusion

Many children grow up with pets, therefore it is important to investigate any potential psychological benefits of PO to child health and development. Due to limitations in study design and data analysis in the research published to date (Purewal et al., 2017), it has been difficult to determine whether any of the associations reported could be explained by residual confounding. Using the ALSPAC birth cohort, we looked at the association between PO and outcomes concerning child development whilst adjusting for a number of socio-economic and demographic factors.

In conclusion, the present study found isolated associations between PO and poorer self-esteem and increased social anxiety, increased hyperactivity and conduct difficulties, poorer cognitive ability in dual attention, consistently poorer educational attainment, but improved language and prosocial development. Our study demonstrates the importance of using large, well-designed longitudinal studies and controlling for key confounders. To further investigate whether PO is associated with child development on a population level, future cohort studies should collect detailed information on children's relationship with their companion animals, including validated measures of pet attachment. Other more powerful approaches such as quasiexperimental design looking at developmental outcomes pre/post-pet ownership are needed to determine whether pets have any causal impact on child development.

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Appendices

## Appendix A: Copies of Questionnaires used in ALSPAC

## Self-esteem

## SPPC

The task was conducted using post-boxes and envelopes. Each envelope corresponded to a single item, comprising two statements, one in blue writing, one in red, for example "Some children are often unhappy with themselves" (in blue) and "Other children are pretty pleased with themselves" (in red). All the statements are shown in Table 40 with the corresponding variable names. There were two post-boxes (one blue, one red), and on each post-box, there were two slots: "Sort of true for me" and "Really true for me". The child was read out each statement and had to decide whether he or she was more like the child in the blue writing or the red (and consequently, whether to post the envelope into the blue or red post box.

The Harter Self-Perception Profile for Children

| Statements shown on each envelope No. | Statement 1 (Blue) | Statement 2 (Red) |
| :---: | :---: | :---: |
| 1 | Some children feel that they are very good at their school work | Other children worry about whether they can do the school work that they have been given |
| 2 | Some children are often unhappy with themselves | Other children are pretty pleased with themselves |
| 3 | Some children feel like they are just as clever as other children their age | Other children aren't so sure and wonder if they are as clever |
| 4 | Some children don't like the way they are living their life | Other children do like the way they are living their life |
| 5 | Some children are pretty slow in finishing their school work | Other children can do their school work quickly |
| 6 | Some children are happy with themselves as a person | Other children are often not happy with themselves as a person |
| 7 | Some children often forget what they learn | Other children can remember things easily |
| 8 | Some children like the kind of person they are | Other children often wish they were someone else |
| 9 | Some children do very well at their classwork | Other children don't do very well at their classwork |
| 10 | Some children are very happy being the way they are | Other children wish they were different |
| 11 | Some children have trouble working out the answers in school | Other children can almost always work out the answer |
| 12 | Some children are not very happy with the way they do a lot of things | Other children think the way they do things is fine |

## Anxiety

## DAWBA

See https://www.dawba.info/py/dawbainfo/b1list.py?language=English

## Depression

## DAWBA

See https://www.dawba.info/py/dawbainfo/b1list.py?language=English

## MOOD AND FEELINGS QUESTIONNAIRE: Short Version:

This form is about how you might have been feeling or acting recently.
For each question, please check ( $\square$ ) how you have been feeling or acting in the past two weeks.

If a sentence was not true about you, check NOT TRUE.
If a sentence was only sometimes true, check SOMETIMES.
If a sentence was true about you most of the time, check TRUE.
Score the MFQ as follows:
NOT TRUE $=0$
SOMETIMES = 1
TRUE $=2$

To code, please use a checkmark ( $\square$ ) for each statement. NOT TRUE SOME TIMES TRUE

1. I felt miserable or unhappy.
2. I didn't enjoy anything at all.
3. I felt so tired I just sat around and did nothing.
4. I was very restless.
5. I felt I was no good anymore.
6. I cried a lot.
7. I found it hard to think properly or concentrate.
8. I hated myself.
9. I was a bad person.
10. I felt lonely.
11. I thought nobody really loved me.
12. I thought I could never be as good as other kids.
13. I did everything wrong.

## Behaviour

RRS
Here are some descriptions of children. Please tick the box that best describes your child

Nowadays my child:
Certainly true; Sometimes true; Not true
F1. Tries to be fair in games
F2. Is restless, runs about or jumps up \& down. Doesn't keep still
F3. Is considerate of other people's feelings
F4. Is squirmy, fidgety
F5. Destroys own or others' belongings
F6. Is spontaneously affectionate to family members
F7. Fights with other children
F8. Is not much liked by other children
F9. Volunteers to help around the house or garden
F10. Is worried, worries about many things
F11. Tends to do things on his own, rather solitary
F12. Is irritable, quick to fly off the handle
F13. Will try to help someone who has been hurt
F14. Appears miserable, unhappy, tearful or distressed
F15. Has twitches, mannerisms or tics of the face \& body
F16. Bites nails or fingers
F17. Is disobedient
F18. Is kind to younger children
F19. Has poor concentration, or short attention span
F20. Tends to be afraid of new things or new situations
F21. Helps other children who are feeling ill
F22. Is fussy, or over-particular
F23. Tells lies
F24. Has wet or soiled himself in the past 12 months
F25. Comforts a child who is upset
F26. Has a stutter or stammer
F27. Has other speech difficulty
F28. Plays imaginatively, enjoys 'pretend' games
F29. Bullies other children
F30. Is inattentive
F31. Gets on well with other children
F32. Doesn't share toys
F33. Cries easily
F34. Is a forceful, determined child
F35. Blames others for things
F36. Shares out treats with friends
F37. Gives up easily
F38. Is inconsiderate of others
F39. Is an independent, confident child

F40. Kicks, bites other children
F41. Is kind to animals
F42. Stares into space (stares blankly)
F43. Tries to stop quarrels or fights

## SDQ

See https://sdqinfo.org/

International Journal of

Review

# Companion Animals and Child/Adolescent Development: A Systematic Review of the Evidence 

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#### Abstract

Childhood and adolescence are important developmental phases which influence health and well-being across the life span. Social relationships are fundamental to child and adolescent development; yet studies have been limited to children's relationships with other humans. This paper provides an evidence review for the potential associations between pet ownership and emotional; behavioural; cognitive; educational and social developmental outcomes. As the field is in the early stages; a broad set of inclusion criteria was applied. A systematic search of databases and grey literature sources found twenty-two studies meeting selection criteria. The review found evidence for an association between pet ownership and a wide range of emotional health benefits from childhood pet ownership; particularly for self-esteem and loneliness. The findings


[^0]regarding childhood anxiety and depression were inconclusive. Studies also showed evidence of an association between pet ownership and educational and cognitive benefits; for example, in perspective-taking abilities and intellectual development. Evidence on behavioural development was unclear due to a lack of high quality research. Studies on pet ownership and social development provided evidence for an association with increased social competence; social networks; social interaction and social play behaviour. Overall, pet ownership and the significance of children's bonds with companion animals have been underexplored; there is a shortage of high quality and longitudinal studies in all outcomes. Prospective studies that control for a wide range of confounders are required.

Keywords: pet ownership; human-animal interaction; review; child development; adolescent development
to children's relationships and interactions with other humans. However, animal ownership is common. Recent figures indicate that 68\% of U.S. households [4] and 46\% of British households [5] include at least one companion animal. Moreover, epidemiological studies suggest that pets are more likely to be found in households with children than in any other household type [6-9]. Although pet ownership and children's bonds with companion animals may have the potential to positively influence child and adolescent development, these relationships have received little attention and a need for research in this area has been recognized [9,10]. Considering that pet ownership also pertains risks, such as zoonoses, bites and asthma/allergies [11], it is important that the impact of pet ownership on childhood development is investigated in detail. Interactions with animals may affect several aspects of human development: emotional, behavioural, cognitive, educational and social.

Companion animals (including horses, dogs, cats, rabbits and other rodents) have the potential to promote healthy emotional youth development in many ways, as shown by research in Human-Animal Interactions (HAI) (the mutual and dynamic relationships between people and animals and the ways in which these interactions may affect physical and psychological health and well-being of both people and their pets [12]). This paper uses the term "youth" development to refer to all age ranges within Infancy ( $0-2$ years), Early childhood ( $2-5$ years), Later childhood (6-12 years) and Adolescence ( $13-18$ years). There is growing evidence that children turn to their pets for comfort, reassurance and emotional support when feeling anger, sadness, or happiness [13-16]. Thus, it is plausible that companion animals may have the potential to encourage better emotional health and reduce anxiety and depression. Physiological mechanisms, such as activation of the oxytocin system may partly explain this reduction of psychological stress for humans who are in contact with animals [17]. However, it is important to recognize that pet attachment may be more important in exerting these potential effects than pet ownership. According to attachment theorists, when attachment behaviours are consistently met by the primary caregiver, children form secure internal working models (a cognitive framework consisting of mental representations for understanding the world, self and others) that are foundational for their ability to make affectionate bonds with others and to create and maintain close relationships [3]. Although psychological theories of attachment concentrate on attachment between humans, research has demonstrated that children display attachment behaviours towards their pets [18]. Because companion animals both give and receive affection, they can contribute to and partially fulfil attachment needs;
therefore, the developmental importance of bonds that children and adolescents form with animals should not be overlooked $[9,19]$. In addition, children who develop poor parental attachment tend to nurture internal working models of distrust with others, insecurity, separation anxiety, low self-esteem, and a propensity for loneliness [20-22]. If children are able to develop secure attachment behaviours with their pets as a substitute, secure internal working models may still develop to some extent [23]. Whether pet attachment and ownership has any impact on child and adolescent development is currently unclear.

Self-psychology (self-esteem, self-cohesion and self-acceptance) is another important aspect of youth development. Particularly in early and pre-adolescence, developmental changes in self-esteem have a significant impact and fluctuate prominently, with large decreases in self-esteem during transition to adolescence [24]. It has been suggested that if companion animals provide support for self-esteem, their greatest influence will be on youths as they approach adolescence (coinciding with increasing experiences of uncertainty) and at this time they may have a higher need for the emotional support they derive from companion animals [25]. Also, during this period cognitive changes in thinking about the self and others, as well as relationships with significant others, such as parents and peers (and perhaps pets), are most common and can indirectly affect self-esteem [25]. If companion animals provide social support [15] and act as catalysts for human social interactions [26], they may reduce loneliness and increase self-esteem. Companion animals have been found to rival and even surpass humans ability to provide important self-object needs, such as self-cohesion, self-esteem, calmness, soothing, and acceptance [27]. Increased self-esteem and self-worth may result in further benefits for individuals with anxiety, depression, behavioural problems and educational attainment.

However, whether causality can be implied to a link between companion animals and child or adolescent self-psychology is yet unknown.

Companion animals may also influence cognitive development. It has been suggested that companion animal ownership may facilitate language acquisition and potentially enhance verbal skills in children [28]. This could occur as a result of the companion animal functioning both as a patient recipient of the young child's babble and as an attractive stimulus, eliciting verbal communication from young children in the form of praise, orders, encouragement, and punishment [28]. In addition, although not empirically tested, the pet may also serve as a subject of conversations that stimulate vocabulary building, when caregivers and children talk about what the pet is doing. Melson [9] reports evidence that companion animals may stimulate a young child's cognitive growth through curiosity and learning, while also providing emotional support and unconditional positive regard. Melson [9] stated that for many children, companion animals are likely to be powerful motivators for learning, perhaps due to children learning and retaining more about subjects they are more emotionally invested in, and due to learning being optimized when it occurs within meaningful relationships. The presence of animals has been shown to elicit immediate positive effects in testing situations of cognition such as memory, categorization and attention [29-34] and studies on language, literacy, and reading ability have also shown a similar positive influence of animal presence [35-37]. It has been speculated that animal interaction may provide opportunities to improve cognitive Executive Functions (EFs) (mental processes that form the basis for planning, attention, memory and self-control) through stress reduction and social support which in turn can affect behaviour and improve academic outcomes [38]. Thus it could be plausible that the long-term presence of pets at
home will have tangible influences on children's cognitive development and educational outcomes. However, the quality of the existing evidence has not yet been reviewed to infer any conclusions.

Most research to date addressing the impact of pets on human health has focused on adults. Less is known about the role pets play in the lives and wellbeing of children and youths, and if pet ownership may provide scaffolding in child development. As outlined above, there is theoretical potential for the role of pets in child and adolescent development, which suggests these relationships are worth exploring further. However, the existing evidence has not been systematically reviewed to identify particular strengths or gaps in knowledge, nor as to whether causality can be implied. Due to study design and quality this is a complex task.

Therefore the objective of this systematic review was to determine the evidence base for the impact of pet ownership and pet attachment on childhood and adolescent development. A broad range of outcomes were reviewed, including emotional, behavioural, cognitive, educational and social developmental. Recommendations for future research are provided to help advance the field of child development and HAI research.

## 2. Materials and Methods

Literature searches of journal articles published between 1960 and 2016 (as of 1 June 2016) were conducted in databases PsycINFO, CINAHL, PubMed, MEDLINE, Web of Science, ScienceDirect and grey literature sources.
Key terms used in searches included pet-related keywords (pet, pet ownership, dog, cat, dog ownership, companion animal, and human animal interaction) and were crossed with developmental-related keywords (child development, adolescent development, psychological, behavioural, educational, cognitive, language and social development, anxiety, depression, self-esteem, loneliness, emotional health). Websites on human-animal interaction were reviewed for possible research articles, including https://www.waltham.com/waltham-research/hai-research/ and https://habricentral.org/resources/browse/journalarticles. In addition, reference lists from relevant journal articles were scanned. It is still possible that evidence remains in unfound grey literature.

The inclusion criteria for the collection of articles included: literature that investigated the effects of pet ownership on emotional, cognitive or behavioural development in children and adolescents without developmental disabilities (infancy up to 18 years). Only articles written in English were included. With the aim of carrying out a broad review of the current relevant literature, restrictions for inclusion were limited; papers were not excluded based on study design and methodology.

Initially, abstracts were reviewed for study selection by the primary author. Research excluded on the basis of content and deemed not relevant to the aim of this paper included Animal Assisted Therapy (AAT), therapy and classroom animals, pets and their effect on physical health (asthma/allergy or other chronic illnesses), ethical and moral development.

The studies were then assessed by the primary author against the OCEBM (Oxford Centre for Evidence-Based Medicine) levels of evidence 2011 [39] to take into account the risk of bias and quality of evidence on which conclusions are based, although no study was excluded based on quality alone due to large gaps in current evidence and poor availability
of good-quality studies within each outcome (refer to Tables 1 and 2 for details of classification).

Table 1. Oxford Centre for evidence-based medicine 2011 levels of evidence.

| Table 1. Oxford Centre for evidence-based medicine 2011 levels of evidence. |  |
| :---: | :---: |
| Level of Evidence | Description |
| Level I | Systematic review of Randomized Controlled Trials |
| Level II | Randomized Trials |
| Level III | Non-randomized controlled cohort/follow-up studies |
| Level IV | Case-series, case-control studies |
| Level V | Expert opinion/Mechanism-based reasoning |

Level I = highest evidence (lowest potential for bias); Level $\mathrm{V}=$ lowest evidence (greatest potential for bias).

## 3. Results

The initial literature searches returned 2959 results. Grey literature searches found an additional
11 references totalling 2970 publications (Figure 1). Forty-one publications remained after the examination of studies against the inclusion criteria. After removing duplicates and the studies not fitting the criteria, 22 studies remained for review.


Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

Among the selected studies, which commonly reported on more than one outcome, 19 reported on the effects of pet ownership on emotional health, five on behavioural development, three on cognitive development, four on educational outcomes, and four on social development. Of the 22 studies, 13 reported cross-sectional data and only two reported longitudinal data on the impact of pets on youth development; a further one used mixed methods, and six qualitative studies were included.

Bias was determined based on the Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence criteria [39]. OCEBM levels of evidence rankings were as follows: twenty papers were ranked level IV, and two papers were ranked at level III. Specific details of the literature can be found in Table 2. The majority of the studies were observational crosssectional questionnaire surveys, or qualitative interviews, therefore were not further evaluated on their methodological quality as they are already considered low or very low levels of evidence according to OCEBM 2011. Refer to Figure 2 for a graphical
representation of study design and risk of bias. Meta-analysis was not appropriate due methodological differences and the number of different outcomes reported.


## KEY

Each bar represents a study, referenced by number. Key study characteristics are represented by the following:


Figure 2. Harvest plot showing evidence for the impact pets have on categories of child and adolescent development. The table consists of eight rows (one for each dimension of development) and three columns (showing the differential effects of the evidence in each category). Each study is represented by a bar in each row; studies can be identified by reference number. Statistically significant effects (use of $p$-values) are indicated with solid blue bars, and studies with no confidence intervals and $p$-values reported are striped bars. The quality of study design is indicated by the height of the bar as categorised by OCEBM level of Evidence 2011. Each bar is annotated with marking to show risk of bias.

Table 2. Evidence for the impact pets have on child and adolescent development.

| Reference No. | Topic | First Author (Year) | $\begin{aligned} & \text { OCEBM } \\ & \text { Level (2011) } \end{aligned}$ | Type of Animal | Sample Size | Participant Age | Participant Gender | Study Type/Design | Confounding Considered? | Outcome |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| [40] | Emotional health (depression) | Rhoades (2015) | IV | Dog (53\%), cat (22\%), hamster, rat, chinchilla, fish, iguana | 332 | 13 years | 91 female <br> 234 male | Cross-sectional survey Control group used. | Yes | Pet owning homeless youths reported fewer symptoms of depression and loneliness than their non-pet owning peers. |
| [41] | Emotional health/ behavioural/social/ cognitive development | $\begin{aligned} & \text { Gadomski } \\ & \text { (2015) } \end{aligned}$ | IV | Dog | 643 | 4-10 years | 289 female 354 male | Cross-sectional survey Control group used | Yes | Having a pet dog in the home was associated with a decreased probability of childhood anxiety in some components (panic, social and separation anxiety) of the SCARED-5 (Screen for Child Anxiety Related Emotional Disorders). However, no difference was found between dog owning and non-dog owning children in their histories of mental health problems. Nor were there significant effects of pet ownership in childhood social, emotional, and behavioural development. |
| [42] | Emotional health (loneliness, attachment, social anxiety) | Vidovic (1999) | IV | $\begin{gathered} \text { Dog (26.2\%) } \\ \text { Cat (9.2\%) } \\ \text { Other } \\ (19.0 \%) \end{gathered}$ | 826 | 10-15 years | 425 female 401 male | Cross- sectional, correlational design Control group used | No | Children who scored higher than average on the attachment to pets scale showed significantly higher scores on empathy and prosocial orientation scales. Pet owners, regardless of age, were not significantly lonelier than non-owners, nor were they socially more anxious. |
| [43] | Emotional health | Mathers (2010) | III | Dog, Cat, Horse or Pony and Other | 928 | 13-19 years | 460 female 466 male | Cross-sectional data from longitudinal school-based population study | Yes | Neither owning a pet nor time spent caring for/playing with a pet appeared to be related to better adolescent emotional health, social development or well-being. Neither did they contribute to negative outcomes. These findings may not apply to other (younger) age groups with a typically higher level of interaction with their pets. |


| [44] | Emotional health (Ioneliness) | Rew (2000) | IV | All | $\begin{aligned} & 32 \\ & 10 \end{aligned}$ | $\begin{aligned} & 16-23 \text { years } \\ & 15-23 \text { years } \end{aligned}$ | 14 female <br> 18 male <br> 3 female <br> 6 male <br> 1 "both" | Qualitative focus groups Qualitative interviews | No | Dogs or animal companions are used as a coping strategy for loneliness. Vulnerable adolescents who are homeless often recognize the therapeutic value of pets. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| [45] | Emotional health (Ioneliness, social support) | Black (2012) | IV | Dogs (67\%), <br> Cats (18\%), <br> Horses (5\%) <br> Rodents and <br> Reptiles <br> (10\%) | 293 | 13-19 years | 158 female 135 male | Cross-sectional survey Control group used | No | High school student pet owners reported less Ioneliness than non-pet owners. Companion animal attachment was positively related to the numbers in the social support network. |
| Reference No. | Topic | First Author (Year) | OCEBM <br> Level (2011) | Type of Animal | Sample Size | Participant Age | Participant Gender | Study Type/Design | Confounding Considered? | Outcome |
| [46] | Emotional health (selfesteem) | $\begin{gathered} \text { Arambasic } \\ (1999) \end{gathered}$ | IV | Dog, cat and other (birds, fish, rodents and turtles) | 612 | 11-15 years | 311 female 301 male | Cross-sectional survey Control group used | Yes | Pet ownership had no significant impact on the selfesteem of war-traumatized children. Self-esteem of pet owners did not differ from self-esteem of nonpet owners, and the type of pet owned also had no effect on self-esteem. |
| [25] | Emotional health (selfesteem, selfconcept) | Van Houtte (1995) | IV | All | 130 | $8-13$ years | 59 female <br> 71 male | Cross-sectional survey Control group used | Yes | Higher self-esteem was reported in pet owners than in non-pet owners, as was a higher autonomy, and self-concept. Attachment to animals was not found to be higher in the pet-owning group and greater attachment to animals was not found to be related to higher scores on the dependent measures. |
| [16] | Emotional health (selfesteem) | Bryant (1990) | IV | All | 213 | $8-13$ years | Not reported | Qualitative interviews Principal component factor analysis | No | Children felt their companion animals benefited them in 4 factors: (1) mutuality (reciprocity in the caring and loving between pet and child); (2) enduring affection (even if the child misbehaves the pet will still love him or her); (3) self-enhancing affection (the child-pet relationship is perceived by children as one that makes them feel good about themselves and imparts a sense of importance) and (4) exclusivity of the child-pet relationship |


| [47] | Emotional health (selfesteem) | Triebenbacher (1998) | IV | All | 436 | 9-18 years | 204 female 232 male | Cross-sectional survey Control group used | No | No direct relationship between levels of self-esteem and pet ownership in school children. An indirect relationship was found between pet ownership and self-esteem mediated by attachment to companion animals. As with other components of psychological health, there may be a relationship between levels of attachment to one's pet and self-esteem benefits accrued. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| [15] | Emotional health (self-esteem/social support) | $\begin{aligned} & \text { McNicholas } \\ & (2001) \end{aligned}$ | IV | All | 22 | 7-8 years | 9 female <br> 13 male | Qualitative interviews | No | Pets were often ranked higher than certain kinds of human relationship, and featured prominently as providers of comfort, esteem support and confidantes for a secret. Dogs and cats offer special relationships for provision of psychological forms of support but not for the more practical problems a child might have to deal with. The fact that cats and dogs frequently ranked higher than many human relationships suggests the value that children place on their pets and the functions they serve. |
| Reference No. | Topic | First Author (Year) | $\begin{aligned} & \text { OCEBM } \\ & \text { Level (2011) } \end{aligned}$ | Type of Animal | Sample Size | Participant Age | Participant Gender | Study <br> Type/Design | Confounding Considered? | Outcome |
| [48] | Emotional health (confidence, tearfulness, self-esteem) | Paul (1996) | III | Dog | 56 | 8-12 years | 27 female <br> 29 male | Prospective questionnaire survey Control group used | Yes | Higher levels of attachment to the dog were positively associated with changes in confidence by the 6 month follow-up, and negatively associated with changes in tearfulness or weepiness by the 12 months follow-up. The positive association between dog attachment and subject children's confidence (at the 6 months follow-up) and its negative association with tearfulness (at the 12 months follow-up) were more consistent with the findings of previous studies which suggest that pet keeping can be associated with higher levels of self-esteem in some children |
| [14] | Emotional health (self-esteem/stress) | $\begin{aligned} & \text { Covert } \\ & \text { (1985) } \end{aligned}$ | IV | All | 285 | 10-14 years | Not reported | Qualitative Interview Mixed methods | No | Early adolescent animal owners had higher selfesteem than non-animal owners. Adolescents felt they gained responsibility (rabbit/hamster), and friendship/love/fun (dog, horse and fish/bird) from pet ownership. Early adolescents used pets for stress reduction. |


| [49] | Emotional health (selfconcept) | Poresky (1988) | IV | All | 188 | Undergraduate students 14-49 years | 99 female 89 male | Cross-sectional survey | No | Self-concepts of undergraduates were related to the age when they had their first pet. Total Positive SelfConcept scores were higher if participants were under 6 years or over 10 years old than if they were between 6 and 10 years old when they had their 1st pet. Similar results were found for the social subscales. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| [50] | Emotional health (self-concept and psychosocial development) | Winsor (2011) | IV | Goat | 15 | 12-17 years | 7 female <br> 8 male | Qualitative interviews | No | Goat ownership enabled children to create positive images of self and life-deriving emotional benefits. Goat ownership provides orphaned and vulnerable children with opportunities for positive social participation and community engagement that can facilitate children's resilience and wellbeing. |
| [51] | Emotional health (psychosocial development) | Davis (1987) | IV | Dog | 22 | 10-12 years | 13 female <br> 9 male | Cross-sectional survey | No | Reasons for acquiring a dog centred on the companionship and emotional dimensions of pet ownership. It appears that the preadolescent does not actually assume a large proportion of daily, routine pet care responsibility, instead they acquire a pet dog for companionship and emotional dimensions of pet ownership. |
| Reference No. | Topic | First Author (Year) | $\begin{aligned} & \text { OCEBM } \\ & \text { Level (2011) } \end{aligned}$ | Type of Animal | Sample Size | Participant Age | Participant Gender | Study Type/Design | Confounding Considered? | Outcome |
| [52] | Cognitive development | Maruyama (2011) | IV | All | 65 | 10-14 years | 43 female 22 male | Mixed methods Cross-sectional survey Qualitative interviews | No | Students who showed stronger attachment with their pets had higher levels of social cognitive development than students who showed weaker attachment with their pets. Students whose parents show more effective guidance on pet care have more advanced skills of thinking and solving problems in flexible manner than students who do not receive any or less guidance on pet care at home. |
| [53] | Educational (biological knowledge/ psychological reasoning) | $\begin{gathered} \text { Geerdts } \\ (2015) \end{gathered}$ | IV | Dog and Cat | $\begin{aligned} & 24 \\ & 96 \end{aligned}$ | 2-6 years | 15 female <br> 9 male | Observations, cross-sectional survey and experimental tasks | No | Both 3 and 5 -year-olds with pets were more likely to attribute biological properties to animals than those without pets. Both older and younger children with pets showed less anthropocentric patterns of extension of novel biological information. The results suggest that having pets may facilitate the development of a more sophisticated, human-inclusive representation of animals. |


| [54] | Educational (biological knowledge) | Prokop (2008) | IV | All | 1541 | 6-15 years | 753 female 788 male | $\begin{gathered} \text { Experimental } \\ \text { task } \end{gathered}$ | Yes | Experiences with rearing pets significantly contributed to children's knowledge about animal's internal organs. Children who reported keeping 2 or more animals acquired better scores than children keeping only 1 or no animals. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| [55] | Educational/ Emotional health | Svensson <br> (2014) | IV | Dog and Cat | 24 | 4-5 years | $\begin{gathered} 12 \text { female } \\ 12 \text { male } \end{gathered}$ | Qualitative interviews | No | The pet supports the child in the learning and development process by (I) Developing empathy and emotions; (2) Being good at school-related tasks. Pets provide children with positive experiences and a sense of feeling good. |
| [56] | Social development/ educational/ cognitive development | Poresky (1989) | IV | All | 88 | 3-6 years | Not reported | Cross-sectional survey /interview | Yes | Developmental benefits were primarily in the children's social domain including social competence, empathy, and pet attitudes. "Pet bonding" appeared to be a stronger determinant of the pet associated benefits than "pet ownership". Children with companion animals and a better home environment showed higher age-adjusted child development scores. Intellectual development benefits were also associated with the strength of the bond between the child and his/her pet. Selfreliance and independent decision skills were higher in the children who have pets. |
| [19] | Socio-emotional/ behavioural development | Melson (1991) | IV | All | 120 | 5,7,10 years | Not reported | Cross- sectional survey/ individual interview | No | Among kindergarten children, perceived competence was positively and significantly associated with diverse dimensions of attachment to the pet. This was not found in older children. Pet attachment was higher for older children and those whose mothers were employed. |

### 3.1. Emotional Health Outcomes

Nineteen of the 22 studies were devoted to children's emotional health. A wide range of emotional health benefits from childhood pet ownership were identified.

### 3.1.1. Anxiety

Two studies measured anxiety as an outcome in youth pet ownership. Having a pet dog was associated with a decreased likelihood of general anxiety ( $12 \%$ of children with dogs met the clinical cut-off value for anxiety compared with $21 \%$ children without dogs) as measured by commonly used and validated mental health assessment tools, specifically Panic ("My child gets really frightened for no reason at all"), Separation Anxiety ("My child is afraid to be alone in the house") and Social phobia/anxiety ("My child is shy"), in an American study of children aged $4-10$-years in a paediatric primary care setting [41]. However, no evidence of a difference was found for Generalized Anxiety ("People tell me that my child worries too much") and Significant School Avoidance ("My child is scared to go to school"). In contrast, in a Croatian study of 10-15-year-old children, pet owners (dog and cat) had no difference in validated social anxiety measures compared to non-pet owners [42]. In sum, these studies illustrate some potential of pet dogs to prevent child and adolescent anxiety, specifically separation and social anxiety disorders, but the small number of studies and mixed results
warrant further research. Whether pets can reduce more general child anxiety is unknown.

### 3.1.2. Depression

There is again a marked lack of research focusing on the effects of pet ownership on depressive symptoms in children and adolescents. Findings of the studies included in this review should be interpreted with caution; there is likely to be an indirect effect of pet ownership on depression, perhaps mediated by self-esteem or loneliness/social isolation.

In one study, pet owning homeless adolescents utilizing two Los Angeles drop-in centres reported fewer symptoms and lower average scores of self-reported depression measured by the 10-item Centre for Epidemiological Studies Depression Scale (CES-D) (average score of 7.8) in comparison to non-pet owning peers (10.2) [40]. However, data from an Australian school-based population study show pet-owning youths of similar ages (13-19 years) did not have better self-reported emotional health or well-being, suggesting findings may be different in non-homeless youths [43].

The potential protective effects of pets may also differ by age group. Prospective research in 8 -12-year-olds found that high levels of attachment to a pet dog were negatively associated with maternal reports of tearfulness and weepiness at a 12 months follow up ( $p<0.01$ ) [48]. However, the impact of dog ownership on depressive symptoms in younger children measured by the Pediatric Symptom Checklist 17 (internalizing symptoms subscale) showed no significant effects, and in addition no difference was found between dogowning and non-dog-owning children in their histories of diagnosed mental health problems [41]. Therefore it could be speculated that the relationship with the animal may be of more importance in conferring psychological benefits than pet ownership alone.

### 3.1.3. Self-Esteem

Nine studies investigated the impact of pets on the self-esteem and self-concept among youths. No effect on self-esteem was found in pet-owning war-traumatized children (11-15 years) in Croatia using the Croatian Version of Rosenberg's Self Esteem Scale (SES) [46]. In the same study, the type of pet owned had no effect either on validated self-esteem measures. In a different study of school children aged 9-18 years, children's attachment to pets mediated the relationship between self-esteem as measured using validated self-report measures [47]. Therefore, there may be a relationship between the level of attachment to one's pet and selfesteem benefits accrued. In addition, prospective research found (using maternal reported data) that higher levels of children's ( $8-12$ years) attachment to a pet dog were positively associated with changes in their confidence level ( $p<0.005$ ) over a 6 months period [48].

In contrast, in a mixed-methods study of children aged 10-13 years, pet owners in fifth ( $\mathrm{m}=16.7$ ) and sixth grade ( $m=17.2$ ) reported higher levels of self-esteem than non-pet owners ( $m=20.0, m=20.8$ ) (lower mean indicative of greater self-esteem) ( $p<0.04$ ) and pet owning sixth graders had higher self-concept scores in comparison to non-pet owners in the same grade (pet owners: $\mathrm{m}=94.2$, non-pet owners: $\mathrm{m}=83.2$ ) ( $p<0.001$ ) [25], even though greater attachment to pets was not related to self-esteem or self-concept. However, in the same study, children aged 8-10 did not differ in terms of self-esteem compared to non-pet owners, suggesting that pets exert their greatest influence during pre-adolescence and adolescence [25]. Other studies also indicate that pet ownership alone is sufficient to have a positive effect on self-esteem or self-concept, independent of pet attachment. Among 8-13-year-olds, qualitative research supports the finding companion animals increase child and adolescents self-esteem and self-enhancing affection-the perception that the child-pet relationship imparts a sense of self-importance and makes them feel good about themselves [16]. Further qualitative data supports this. In a study of $7-8$-year-old children examining representations of social support from companion animals using a story-based methodology, relationships with pets were ranked higher than human relationships by children as providers of both self-esteem and support [15]. Generally, dogs and cats were deemed better providers of psychological support as they consistently achieved higher rankings than many of the child's human relationships, such as making one feel better about oneself, but not for practical problems children may have to face.

Furthermore qualitative study of early adolescents (10-14 years) found pet owners to have higher self-esteem than non-pet-owning peers amongst other pet-owning benefits such as friendship and stress reduction [14]. Importantly, a long term effect may be present; the self-concept of undergraduate students (14-49 years) was related to the age they were when they had their first pet [49]. Self-concept scores of undergraduate students were higher if participants were in early childhood (below 6 years old) ( $m=349.42$ ) or in adolescence (over 10 years old) ( $m=361.81$ ), than if they were in middle childhood (between 6 and 10 years old) ( $m=342.14$ ) when they owned their first pet.

The psycho-social wellbeing of youths due to goat ownership has been examined in Western Kenyan culture. A qualitative study using thematic analysis found that after orphaned 12-17-year-old children were given goats to care for, the development of pride, self-concept and self-worth was much improved due to goat ownership [50]. Owning goats, which are typically kept as property rather than pets, enabled children to create positive images of the self and of life, increased resilience and coping skills and increased social participation within the community. However, it must be recognised that goat ownership in this case may imply an increase in wealth therefore child welfare may not have been directly affected by interaction with the animals, but instead by an escape from poverty.

### 3.1.4. Loneliness

Loneliness is likely a precursor for anxiety, depression and low self-esteem. There is some evidence that pet ownership may protect youths from loneliness and social isolation, and therefore may help to prevent depression. Pet-owning homeless youths aged 15-23 years reported fewer symptoms of both loneliness quantitatively (UCLA Loneliness Scale score of 1.8, compared to 2.3 among non-pet owners) [40] and qualitatively [44] than their non-pet owing peers in addition to reduced symptoms of depression. A large proportion of these youths had pet dogs ( $53 \%$ ) and other companion animals,
which they recognized as a coping strategy for loneliness due to their therapeutic nature and value [44].
The protective impact of pet ownership on loneliness has also been observed in less vulnerable populations. For example, high school students (13-19 years) who owned a pet reported significantly lower scores of loneliness (mean score of 33.7) than non-pet owners (39.5) using validated scales [45], regardless of ethnicity, gender, age, and family composition. In addition, loneliness scores were not affected by length of relationship with the pet or the number of pets owned. Companion animal attachment was positively related to the number of humans in the students' social support network, suggesting that pet attachment may play an important role as a predictor. However, another study using validated measures of socio-emotional development of children aged 10-15 years found that pet owners were no more or less lonely than non-pet owners, although they did show a high degree of emotional closeness to their pets [42]. The impact of pet ownership on loneliness in younger children has not been investigated.

### 3.2. Behavioural Outcomes

There is mixed evidence on whether pet ownership affects behavioural outcomes in children or adolescents as shown in Figure 2. Amongst U.S. kindergarten children aged 5 years, perceived competence (cognitive competence, physical competence, peer acceptance and maternal acceptance) measured by parental report, was positively associated with pet attachment [19]. However, in the same study among older children (7 years and above), attachment to pets and perceived competence were generally unrelated. In a UK prospective follow up study, mixed equivocal findings were demonstrated in middle childhood ( $8-12$ years). Findings suggest that behaviour improves when families first acquire a pet dog, but does not differ from non-dogowning children longitudinally; dog owning children were reported to be less naughty, less argumentative, better behaved, and more co-operative by their mothers at the 1 month follow-up after acquiring a pet dog than non-dog owners, but there were no differences thereafter at the 6 and 12 months follow ups [48]. In addition, and perhaps surprisingly, caring behaviour was reported to decrease in dog-owning children in that study; however, it was not specified who, pets or humans, were the recipients of the caring behavior. Similarly, an American study of children in a paediatric primary care setting found no differences in the behaviour of dog owning children and non-dog owners aged 4-10 years measured by the Strengths and Difficulties Questionnaire [41]. In contrast, three other studies demonstrated how pet ownership increased behaviours of responsibility. Qualitative data from homeless youths suggests that dogs provide the opportunity to be responsible and care for another being, which in turn promoted healthier self-care choices and decisionmaking, for example, less alcohol consumption and improved financial choices [44]. Finally, a significant main effect was found ( $p=0.006$ ) for pet owners aged $8-13$ years old showing greater autonomy (third grade $\mathrm{m}=$ 13.3 , fourth grade $m=13.8$, fifth grade $m=14.6$, sixth grade $m=14.9$ ) than non-pet-owning children (third grade $m=14.9$, fourth grade $m=16.0$, fifth grade $m=16.0$, sixth grade $m=15.8$ ) (lower mean indicative of
greater autonomy). Explicitly, pet-owning individuals were more able to see their parents in roles other than the parental role and thus were deemed as more autonomous than non-pet owners [25]. The study suggested that pet ownership has the potential to foster the development of autonomous characteristics such as responsibility and self-reliance [25].

### 3.3. Cognitive Outcomes

Three studies have addressed the impact of pet ownership on child and/or adolescent cognitive development. A mixed methods thesis paper found that 10-14-year-old students with a stronger attachment to their pets had higher levels of validated social-cognitive development scores, for example in perspective-taking abilities, in comparison to students with a weak attachment to their pets ( $p<0.001$ ) [52]. However, no comparisons with non-pet owners were made. Pet care guidance also played a role; in the same study, students whose parents displayed more effective guidance of pet care showed stronger attachment with their pets $(\mathrm{m}=28.19)$ than students who received less or no parental guidance on pet care at home ( $m=14.28$ ), and had more advanced skills of cognition and flexible problem-solving than students who received little or no guidance ( $p<$ 0.05 ) [52]. However, in a cognitive subscale of Attention (Pediatric Symptom Checklist 17) no differences were found when comparing dog-owning children to non-dog owners aged 4-10 years [41]. Lastly, research on companion animal bonding and young children's social development found higher scores on parent reports of self-reliance and independent decision skills in strongly bonded pet-owning children compared to weak and moderately bonded pet-owning children, and non-pet-owning children ( $p<0.05$ ) [56].

### 3.4. Educational Outcomes

Four studies examined the impact of pets on educational outcomes. Pets may be useful in the engagement of both verbal and physical reciprocal behaviours. In a study investigating the effects of exposure to animals on children's biological concepts, 2-6-year-old children with pets were more likely to attribute biological properties to animals than those without pets, and showed less anthropocentric patterns of extension of novel biological information, suggesting that having pets increases children's knowledge of biology [53]. Thus, pet ownership could facilitate the development of a more sophisticated, human-inclusive representation of animals in children [53]. Similarly, 6-15-year-old children who owned two or more pets scored better on factual knowledge of animal anatomy than non-pet owners [54]. Furthermore, a Swedish study including qualitative interviews regarding the impact of pets on children's development and desire to learn ("what can you learn from your pet?" and "What can your pet teach you?") showed that owning dogs and cats may facilitate 4-5-year-old children's learning and development process. Specifically, pet ownership aided the learning process in two sub-categories: 1. Developing empathy and emotions, and 2. Being good at schoolrelated tasks [55]. Pets provided children with positive experiences and a sense of feeling good whilst increasing their knowledge of social behaviour. Exemplified sentiments expressed by many children in this study state "an animal listens only to you and gives you their full attention". Such attention, in turn, may give children a sense of importance, satisfaction and a desire to learn more [55]. Finally, an early study of receptive vocabulary skills found bonding with a pet among 3-6-year-old children resulted in higher verbal intelligence scores in children moderately bonded to their pets ( $m=124.20$ ) in comparison to non-pet-owning children (m $=111.25$ ) [56]. No research has been carried out to investigate the impact of pet ownership on later adolescent educational outcomes.

### 3.5. Social Development Outcomes

The role of pet ownership and bonding with a pet among the social development of 3-6 year olds children has been evaluated by parental reports [56]. It was concluded that young children derive developmental benefits (social competence, empathy, and more positive attitudes toward pets) from their interaction with their companion animals. Bonding with pets appeared to be a stronger determinant of these associations than pet ownership. Taken together, children who bonded well with pets and children with better home environments had higher age-adjusted child development scores.

In contrast, one study showed that pet ownership might actually be detrimental to children's social development, and may even reduce levels of social interaction in some children [48]. In a prospective study investigating the effects of obtaining new pet dogs, children's attachment to pets at the 12 months follow up was associated with increases in the amount of time spent alone between baseline and 12 months ( $p<0.05$ ), and inversely associated to changes in children's time spent with family ( $p<0.05$ ) and friends ( $p<0.05$ ), suggesting a that strong bond with a dog may result in less time spent with others. However, the study does not examine the quality of interactions; it cannot be assumed that quantity of time spent in social relationships with humans alone determines the quality of social interaction. A different study showed no evidence of an impact of dog ownership on social Externalizing outcomes (such as sharing and fighting behaviour, and understanding others feelings) in children aged 4-10 years [41]. Again, no effects of pet ownership on social measures were found in 13-18-year-old adolescents measured by the Pediatric Quality of Life Inventory which assesses social functioning and psychosocial health summary scores [43].

## 4. Discussion

The impact of pet ownership on child and adolescent development is a promising area of research but current evidence base does not permit firm conclusions. This paper provides a review of the evidence on the effects of pet ownership on emotional, behavioural, cognitive, educational and social development. Overall, the evidence suggests that pet ownership, and dog ownership in particular, may benefit these outcomes for children and adolescents. However, the evidence is mixed partly due to a broad range of different methodological approaches and varying quality of studies. In regards to the quality of the studies, the majority of the literature is categorised at low levels (levels 3 and 4) on the OCEBM criteria [39]. In addition, small samples sizes are common, and confounding factors have not always been accounted for. Therefore, the findings from which conclusions are drawn should be interpreted with caution.

Diagrams have been conceptualized for the plausible relationships between pet ownership and children's emotional, behavioural and cognitive outcomes (Figures 3-5). These hypothesized diagrams focus strongly on the links found in the current literature within the field. We are well aware that the mechanisms behind these developmental processes are likely to be much more complex; they were simplified to focus on the plausible links found in this review, and for ease of interpretation. In addition, it is important to take into account the methodological issues, mixed results, and lack of replication of the literature used to postulate these hypothesized mechanisms. High quality research is needed to determine specific effects in pet type and child age, and to further explore if these links are truly causal. What follows is a brief summary of the results along with supporting research, followed by gaps in the literature and suggestions for further research directions.


Figure 3. Hypothesized links for the impact of pet ownership and attachment on emotional health outcomes that postulates (a) physiological responses from pet interaction result in stress reduction (green pathway), and (b) anxiety, separation anxiety and depression are indirectly reduced by a wider social network and increased social support and companionship from pets (blue pathways) and (c) pet attachment may be indirectly affected by primary caregiver attachment (mother figure) through the internal working model (red pathway).


Figure 4. Hypothesized links for the impact of pet ownership and attachment on self-esteem, and loneliness that postulates (a) pet attachment directly increases self-esteem, and self-esteem and self-concept are increased indirectly through a wider social network resulting in increased social support (green) and (b) loneliness is reduced through a wider social network gained from having a pet, and increased social support and companionship from the pet (blue) and (c) relationship and communication skills are honed through increased social interaction (red).


Figure 5. Hypothesized links for the impact of pet ownership and attachment on cognitive and educational outcomes, that postulates (a) Executive Functions are indirectly supported by stress reduction and increased social support, and therefore a reduced incidence of problematic behaviours follows (green) and (b) improved academic outcomes may result due to education being positively affected by improved executive functions and increased social support (blue) and (c) social cognition and language acquisition are enhanced by communication and social interaction with pets (red).

### 4.1. Emotional Outcomes

Overall, current evidence suggests that pet dogs may be beneficial in terms of preventing separation anxiety and social anxiety in both children and adolescents [41,57], however, this requires further investigation, as this finding is not consistent in older children and adolescents [42]. It is unknown whether pet dogs can reduce symptoms of anxiety in children. There is little evidence for any effects for other pet types. In regards to depression, there is a lack of research investigating the impact of pet ownership in youths, particularly in young children under 8 years old. Similar to anxiety, findings in depression seem to be varied. Findings may differ in younger age groups however, due to a typically higher level of interaction such as pet care and therefore stronger pet attachment [51]; the nature of the relationship with the animal may be important in conferring psychological benefits such as depression more likely than pet ownership. Overall it is suggested, but not conclusive, that vulnerable adolescents may benefit from pet ownership in terms of reduced depressive symptoms, and children who are attached to their dog during middle childhood may benefit in terms of resilience to depressive emotions in the long term. For young children, pet attachment seems to be a factor of importance for the prevention of depressive symptoms.

Within emotional health, the effect of pet ownership on child and adolescent self-esteem is currently the most studied outcome. Research generally demonstrated that children who grow up with companion animals showed higher levels of self-esteem and developed into more socially competent adults than children who do not grow up with companion animals [10]. Some studies found pet attachment to be a mediator of a relationship between self-esteem and pet ownership [47]; this is supported with longitudinal prospective research [48]. Therefore a relationship may exist between the level of attachment to one's pet and self-esteem levels, similar to other components of psychological health. However, not all research is consistent with this suggestion; higher self-esteem and self-concept have been reported in pet owners irrespective of pet attachment $[14,16,25]$ although causation cannot be implied here due to cross-sectional and qualitative study
designs. Critical ages for the impact on pet ownership for self-esteem have been suggested [25]; pet ownership may have the greatest influence in children under 6 years old, and preadolescents and adolescents over 10 years old. Lastly, the majority of the evidence suggests that pets are useful in combating loneliness. Pet attachment was positively related to the number of humans in their social support network. This suggests pet attachment may again play an important role or, it could be that these people are better at forming attachments in general with humans and/or pets, but again due to study design, causation is not justified. The impact of pets on measures of loneliness in children under 10 years of age has not been investigated.

The significant findings in emotional health are consistent with research involving interaction with dogs as opposed to pet ownership, in 7-12-year-old children with insecure or disorganized attachment in stressful situations [58,59]. Dogs caused children's cortisol levels to drop significantly faster and to lower levels after a stressor. It was concluded children with insecure and disorganized attachment may profit more in regulating their physiological stress levels from the interaction with a friendly dog than with a human or toy dog. The data suggest an important role of physical contact in the reduction of stress, although findings on the benefits of physical contact with companion animals are still generally unclear [60]. Further explanations behind why dog interaction and ownership may have such benefits for anxiety in youths center on the social catalyst effect [61], which states that pet dogs may stimulate conversation and alleviate social anxiety. Hormonal effects may also play a role; companionship and interaction with dogs can also lead to increased levels of oxytocin and reduced levels of cortisol, attenuating physiologic responses to stress and anxiety [17].

Importantly, child-dog interactions could prevent the evolution of emotional problems into full-fledged mental, emotional or behavioural disorders during adolescence or later life during adulthood [41], perhaps due to increased emotional support and resilience. This applies in particular to vulnerable (homeless) youths as companion animals provide emotional support in the form of loving relationships [40]. Furthermore pet therapy has the potential to reduce depressive symptoms and increase mood in children suffering from chronic physical illnesses such as haematological and oncological disorders, cystic fibrosis, diabetes, transplants, and other medical disorders [62].

Further research is needed as to whether childhood pet ownership may have similar effects.
Both quantitative and qualitative research find self-importance to be a common theme; pets act as a form of psychological support by making youths feel good about themselves and are enabled to create positive images of the self [15,16]; this also applies to non-western cultures [50]. These findings are promising and suggest that pet ownership should be investigated as a strategy to increase self-esteem in developing youths. Findings that support this include research carried out using a horse therapy program; although no intervention effect was found on self-esteem, an increase was found in perceived social support in comparison with the control group [63]. Pets such as horses and dogs are most likely to increase social circles and the number of human contacts, and if so, could increase emotional health outcomes such as self-worth and self-esteem. Overall the current research generally displays potential for pets to increase children and adolescents' resilience and self-worth. In particular, adolescent loneliness and isolation is an important issue, and if untended can manifest as a host of various physical and emotional problems, including anxiety, depression and low self-esteem [64] and poor academic achievement [65]. Companion animals are used as a coping strategy for loneliness in youths due to their therapeutic nature [44]. It is possible that companion animals offer a reciprocal affectionate and nonjudgemental relationship, which has obvious benefits for child and adolescent development. Notably, it is difficult to unravel other variables that may explain why pet owning youths seem to appear less lonely. The
importance of parenting styles has previously been suggested [14], which may differ in pet owning families, and is likely to increase responsibility, autonomy, empathy and socialization in comparison to non-pet owning households. However, pet ownership may independently impact on the development of empathy and socialization without the influence of parenting style; it is plausible that parents who keep household pets are actually fostering these qualities by proxy [45], therefore lessening childhood loneliness. Further well-designed studies are recommended for additional clarity, to infer causality, and to conclude whether there is a link between companion animals and child and adolescent loneliness.

### 4.2. Behavioural Outcomes

The evidence is mixed for the impact of pet ownership on child and adolescent behavioural outcomes. Results of different research studies are not consistent on whether perceived competence in children is positively and significantly associated with pet ownership and/or attachment, dependent on age [19]. There appears to be no long-term behavioural benefit from acquiring a pet dog, as child behaviour only improves when families first acquire the dog $[41,48]$. Nevertheless, there is literature to suggest that pet ownership and pet care in particular is associated with increases in positive behaviours such as responsibility [ $10,25,44,45,66]$. Therefore pet ownership and pet care responsibilities may encourage positive behavioural development in terms of independence, and other autonomous characteristics such as self-reliance [25]. Further well designed research is needed using objective measures of behaviour, such as school reports. In addition, as child and adolescent behaviour can predict future educational attainment [67], it would be interesting to explore the potential links between pet ownership, behavioural outcomes and other indirect developmental relationships. Other nonexperimental mechanism-based reasoning reports suggest that pet owning children are likely to show decreased violence and antisocial behaviours, as pet ownership has positive effects of a wide range of developmental outcomes including social and moral development [68]. However, no evidence of this was found in studies reviewed here. The idea that childhood and adolescent behaviour may predict future antisocial activity is not new. Childhood disruptive behaviour has powerful long-term effects on adult antisocial outcomes, which continue into middle adulthood [69]. If pets can promote such positive behaviour, they may be involved in early interventions. However, there is very little research in the area, and there are findings to argue against this claim; among youth offenders childhood bonding with a pet was not related to antisocial personality traits [70].

### 4.3. Cognitive Outcomes

Pet ownership, attachment and parental pet care guidance were associated with higher levels of some areas of social cognitive development for example perspective taking abilities, and cognitive flexible problem solving skills [52]. Furthermore, self-reliance and independent decision skills were higher in pet-owning children compared to children who do not have pets [56]. However, other areas of cognition were not affected in a similar manner; no differences in attention were found in dog owning children compared to non-dog owners [41]. Caution must be taken when interpreting findings. In addition to their inability to establish causality, most studies inadequately controlled for potential confounding factors. It cannot be concluded pet care guidance increases cognitive function with respect to higher level thinking and flexible problem solving. These higher cognitive skills may instead be due to good parental guidance in general rather than pet care guidance. Other important confounding factors also need to be ruled out such as the quality of children's home environments, beyond the presence of animals, which has been linked with both the concurrent and longitudinal cognitive development of preschool children [28,56,71].

Current research advocates pet ownership and animal interaction as a catalyst for learning and progressing in both cognitive and psychosocial domains [29-33]. The mechanisms behind the influence of pet interaction on cognitive development are not fully understood. Speculations include improved cognitive Executive Functions (EFs) through stress reduction and social support which in turn can positively affect behaviour and academic outcomes [38] however, this remains to be tested. Research has suggested that pets may aid a quicker progression of the four major periods of cognitive development [72] (sensorimotor stage, preoperational stage, stage of concrete operations, and the formal operation stage [73]) however, further study is warranted. As animals are "predictably unpredictable" [9], pet behaviour to the observing child represents what cognitive development theory [73] argues is the route of all learning, namely, cognitive incongruity, moderate discrepancy from established schema, and novel information [10] however, this statement does not take into account that pet behaviour varies greatly and remains to be tested empirically. Younger children (i.e., children in the preoperational stage) may be beginning to learn and develop their concept of social relationships, and interacting with pets may promote young children's cognitive development; existing research appears to support this idea [52,72]. Introducing children to animals during such a sensitive period may produce optimal results in terms of promoting their abilities to enhance social cognitive development [52], in particular perspective taking abilities, although more empirical research is needed to infer this. Possible mechanisms may include pet ownership enhancing the progression of the child's internal thinking (i.e., reorganization and advancement)
which shapes their schema and may enhance overall cognitive development. In addition, as children include their pets in physical, imaginative, and free play [72], social and cognitive functioning may be enhanced due to practicing problem solving abilities and creativity [74]. Other than social-cognition, further well-designed research is required on pet ownership that examines mainstream cognitive outcomes such as executive function, memory and IQ.

### 4.4. Educational Outcomes

Pets have the potential to improve educational outcomes. For many children, companion animals are likely powerful motivators for learning [9] and development [9,55,75]. Pets have also been found to enhance performance in school-related tasks [55] and enrich children's vocabulary [56]. Although mechanisms are not clear, this is possibly due to children learning and retaining more about subjects they are emotionally invested in, and furthermore learning is optimized when it occurs within meaningful relationships. Pets also engage children in both verbal and physical reciprocal behaviours [53]. Interestingly, research has demonstrated that pet owners benefit from more advanced biological knowledge than non-pet owning children suggesting that pets facilitate the development of a more sophisticated, human-inclusive representation of animals, knowledge about the internal structure of animals and factual anatomy [53,54]. So far, no research has investigated the impact of pets on later adolescent educational outcomes. The support of pets in children's learning process is also demonstrated in research involving classroom animals with respect to reading skills [35,36], social functioning and academic competence [37], emotional stability within school and attitudes towards school [76]. The evidence base is strongest for dogs; the presence of a dog in the classroom has been shown to help children exercise better cognitive executive functions and perform better academically [77]. Further research is required to investigate whether pet ownership is associated with academic attainment.

### 4.5. Social Development Outcomes

Findings are mixed in terms of the impact of pet ownership on children's social and socio-emotional development. Childhood pet ownership encourages healthy social development in terms of social competence, social networks, social interaction, social communication, empathy and social play behaviour, leading to higher age-adjusted developmental scores $[10,56,68]$. However, it must be noted that pet bonding and, therefore, pet attachment appeared to be a stronger determinant of these benefits than pet ownership [56]. The finding that pets increase social networks is encouraging; how a child develops is strongly influenced by the child's social network, for example the support provided by social networks can enhance self-esteem and contribute to mental health, by providing a buffering, protective function against psychosocial stress [78]. In addition, the finding that pets increase social play behaviour and communication is important, and strongly suggests that pets have the potential to encourage the development of effective socially interactive relationships with others. Alternatively, pets might actually be detrimental to social development and may even reduce levels of social interaction with family and friends in some children [48] which is likely due to the child substituting human contact for interaction with their pet. However, the reduced quantity of social interaction does not mean the quality of these human relationships will suffer. In addition, no significant effects were found on the impact of childhood dog ownership on social externalizing outcomes (such as sharing, fighting and understanding others' feelings) [41], nor social functioning in adolescents [43]. Other research finds social provisions in children are enhanced by classroom pets with children displaying more prosocial behaviours with peers [37]. Further high-quality research is needed to infer causality. In addition the majority of the research has been conducted when interactions on social media were not yet very common. Children's experience of "expanded" social networks is very different now than it was a couple of years or decades ago. As more and more children experience friendships (and abuse) online and on social media, the effects of pets on the feelings of social isolation in this context would be particularly cogent.

### 4.6. Risks/Costs to Children and Adolescents Associated with Pet Ownership

Along with the benefits of the ownership of companion animals, which may include improved child behaviour and development, certain negative consequences have been noted. These include zoonotic infections [79], allergy and asthma [80], bites and other injuries [11] and the psychological and emotional costs due to pet bereavement [81]. Young children are at a greater risk of zoonotic infection; this is a particular concern for immunocompromised children (reviewed in [82]). In addition, children are at a greater risk of animal bites from a household pet (e.g., about 72\%-80\% of children are bitten by a familiar dog [83-85]). Children under 5 years of age are significantly more likely than older children to provoke animals before being bitten and are most at risk of serious injury [ $83,84,86,87$ ].

### 4.7. Methodological Limitations

The review reveals mixed evidence and conflicting results. In studies investigating pet ownership on human health and development such inconsistent findings are not infrequent due to use of a
wide diversity of designs, small effect sizes and small and homogeneous self-selected samples [88,89].
In addition the research findings within the field are often limited by lack of replication [90].
This review highlights a number of particular methodological limitations that require addressing in future studies. If these concerns are addressed, then the research quality in the field will be significantly improved.

Firstly, there is inconsistency in how studies classify non pet owners. The studies reported here did not appear go into any detail regarding comparators; for example youths with recently deceased pets are likely to be regarded as non-pet-owners. Papers commonly specify non pet owners as "non-dog" and "non-cat" owners, however, this frequently fails to account for potential effects of other companion animals on the outcomes of interest. Pet owners are often treated as one homogenous population without consideration of differences between them or of differences in species owned, their attitudes to pet ownership and pet attachment, both of which are likely to impact potential benefits from their interaction with their pets. Secondly, in some studies, the reliance of subjective self-reported data in place of objective validated outcomes is problematic, due to an increased probability of false negative and false positive reporting.

Thirdly, the majority of studies to date have been cross-sectional, which means that the direction of the association between pet ownership and different aspects of child development cannot be determined. For example, children deemed by their parents as more responsible may be viewed as more ready to take on the role of pet owners, and therefore, more likely to get a pet than children who are viewed as less responsible or mature. This reverse causality could still result in a positive association between pet ownership and responsible behavior, but in this case, responsible behavior would cause pet ownership and not the other way around. Due to the nature of the independent variable (owning a pet or not), research in this field cannot be truly experimental, and therefore prospective studies are needed to determine the temporal direction between pet ownership and the outcomes [10,25].

Fourth, longitudinal and prospective studies in pet ownership and child development are needed to determine the long-term consequences for children of establishing relationships with pets and other animals. A lack of longitudinal and epidemiological data in this area hampers the development of appropriate and effective interventions [89].
Fifth, research into the effects of animals on human health and development have also been historically weak in terms of statistical power and the ability to appropriately control for confounding variables [90]. Pet ownership has been associated with numerous socio-demographic factors [6,7,91-93]; the majority of studies in this review have failed to take into account some of these factors. Conflicting findings may be due, at least in part, to the inadequate control of variables identified as potential confounders. Furthermore, a child's interaction with pets is mediated by interactions with adults, siblings, and peers. Therefore, a life-course approach is needed to specify mediational models and pathways to later developmental, and to understand the different forms of social and emotional support pets may provide, as well as how this support is contextualized within adult, peer and pet relationships over time [66,89]. For example, a pet may positively influence emotional and mental health of both children and adults within a family unit. Because of the reciprocal nature of all relationships, children who show more positive behavior due to bonding with their pet, may elicit more positive responses from their parents, thus contributing to an overall positive family functioning. In turn, parents, who benefit from lower levels of anxiety or depressive symptoms from owning the same pet, may interact more positively with their children.

Another important limitation for the majority of studies included in the review is that it is not possible to know whether families with children having no or minimal challenges with emotional health or general developmental difficulties are more or less likely to live with companion animals, compared with families with children having challenges.

Last, it is possible that the published literature on the impact of pets on children's health is biased by selective publication of positive results. For example, studies demonstrating a significant effect of pet ownership may be more likely to be published and cited by others than studies with negative findings. The lack of negative/null findings illustrated in Figure 2 suggests a high likelihood of this "file drawer effect," which may skew the available scientific literature on human-animal relationships [90].

## 5. Conclusions

In summary, current evidence suggests that overall, pet ownership may be beneficial to child and adolescent emotional, cognitive, behavioural, educational and social development. Although the majority of studies performed to date had methodological weaknesses, the pattern of findings among sub-populations and age groups suggests that companion animals have the potential to promote and contribute to healthy child and adolescent development. However, there is a scarcity of research to elucidate the mechanisms through which pet ownership promotes child development. This is required to identify the processes that underlie the observed relationship between pet ownership, pet attachment and child development. Future research should examine the potential effects of different pet types. Although the majority of research has taken into account the types of pets children owned, dogs appear to be the most researched and beneficial, perhaps due to a higher level of interaction and reciprocation in comparison to other pets. There is little understanding so far of potentially differential effects of different types of pets on specific psychological, behavioural, and social problems [94]. Further research is required to investigate the mechanisms through which pet ownership promotes child and adolescent development. Future studies must better account for confounding variables, and preferably use longitudinal and as strictly controlled designs as possible in order to infer causality.

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Socio-demographic factors associated with pet ownership amongst adolescents from a UK birth cohc Rebecca Purewal ${ }^{1{ }^{*}}$, Robert Christley ${ }^{1}$, Katarzyna Kordas ${ }^{2,3}$, Carol Joinson ${ }^{3}$, Kerstin Meints ${ }^{4}$, Nancy Ge Check for Carri Westgarth ${ }^{1}$


#### Abstract

Background: In developed nations, pet ownership is common within families. Both physical and psychological health benefits may result from owning a pet during childhood and adolescence. However, it is difficult to determine whether these benefits are due to pet ownership directly or to factors linked to both pet ownership and health. Previous research found associations between a range of socio-demographic factors and pet ownership in seven-year-old children from a UK cohort. The current study extends this research to adolescence, considering that these factors may be important to consider in future Human-Animal Interaction (HAI) research across childhood.

Results: The Avon Longitudinal Study of Parents and Children (ALSPAC) collected pet ownership data prospectively via maternal reports from gestation up to age 10 years old and via self-report retrospectively at age 18 for ages $11(n=3063)$ to 18 years old ( $n=3098$ ) on cats, dogs, rabbits, rodents, birds, fish, tortoise/turtles and horses. The dataset also contains a wide range of potential confounders, including demographic and socio-economic variables. The ownership of all pet types peaked at age $11(80 \%)$ and then decreased during adolescence, with the exclusion of cats which remained constant (around $30 \%$ ), and dogs which increased through 11-18 years ( $26-37 \%$ ). Logistic regression was used to build multivariable models for ownership of each pet type at age 13 years, and the factors identified in these models were compared to previously published data for 7 year-olds in the same cohort. There was some consistency with predictors reported at age 7. Generally sex, birth order, maternal age, maternal education, number of people in the household, house type, and concurrent ownership of other pets were associated with pet ownership at both 7 and 13 years (the direction of association varied according to pet type).


Factors that were no longer associated with adolescent pet ownership included child ethnicity, paternal education, and parental social class.

Conclusions: A number of socio-demographic factors are associated with pet ownership in childhood and adolescence and they differ according to the type of pet, and age of child. These factors are potential confounders that must be considered in future HAI studies.
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## Background

The study of Human-Animal Interactions (HAI) is an expanding field of research. HAI is the mutual and dynamic relationship between people and animals, and the effects these interactions have on physical and psycho- logical health and well-being of both people and their pets [1]. Potential benefits of pet ownership on the emo- tional and physical health of both adults [2-10] and chil- dren [11-15] have been observed.

Pets may play a distinctive role in supporting wellbeing in adolescence because it is a developmental period characterized by a great deal of emotional and physical change due to sexual maturation. From a psychological health perspective, pet ownership in adolescence has been shown to enhance self-esteem [16-19], decrease loneliness [20-22], and increase resilience to depressive [22] and anxious symptoms [13]. However, the research is not conclusive; some studies have found null effects on these outcomes [23-25]. Pet ownership has also been associated with educational [26] and cognitive development [27] of youths. Dogs in particular have been found by some to improve physical activity [28, 29], although others report no benefit [30, 31].

Mixed findings may in part be due to methodological differences among studies [11]. The inconsistent evidence regarding the health impacts of pet ownership in adolescence is a common problem in HAI studies and may be due to a wide diversity of designs, small effect sizes, and small and homogeneous self-selected samples, as well as incomplete adjustment for relevant con- founders [32]. Methodological limitations also reduce the ability to infer causality [11, 33]. Further research into the health effects of pet ownership during childhood and adolescence is required. The use of appropriate methodology, including adjustment for confounders, is critical to ensure findings are not over-interpreted, nor any tangible associations missed [33].

Socio-demographic factors may explain postulated psychological and physical health benefits of pets [11, 34-37]. Although many studies adjust for at least age and sex of the participants, pet ownership has been associated with other factors [37-40], such as ethnicity, the number of people in a household, the presence of an older sibling, parental education and social class, maternal age at delivery, maternal pet ownership history and housing type [37]. The need to control for confounding factors is recognised; studies have identified socio-demographic differences in ownership of different pets types in adults [34, 36, 41] and children [37, 42], but less so in adolescents [43, 44].

If we are to examine the evidence for health benefits of pet ownership in adolescence, we first need to
understand the factors associated with pet ownership. We need to explore which socioeconomic, demo- graphic and behavioural variables are associated with ownership of different pet types, so that they can be controlled for as much as possible during study design and analysis of data involving HAI. Differences be- tween explanatory factors associated with ownership of different types of pets also need to be examined as differences in the type of people who own them have been found [37, 45] including; social class, education level, household composition, gender of respondents, and house type. Previous research is mostly limited to dog and cat ownership [34, 36, 38].

Birth cohorts are useful sources of data to examine fac- tors associated with pet ownership, and have been used for this purpose in studies of children [37]. However, differ- ences may exist in the prevalence and frequency of pet ownership among children and adolescents, and there may be differences in the variables that explain pet ownership in childhood and adolescence [37, 42, 46, 47]. Furthermore, because youth interaction with pets is mediated by interactions with adults, siblings, and peers, a life-course approach is needed to specify mediational models and pathways in human health outcomes over time [32, 48]. In addition, previous research shows conflicting associations for ex- ample, whether pet owners had higher [36] and lower [41] education levels than not pet-owners. The use of a very large sample in the present study provides advantage over previous research, due to the likelihood of being more representative.

Given the relative paucity of studies on the sociodemographics of pet ownership among adolescents [19, 44], the present study assesses which sociodemographic variables are important in determining pet ownership of different types of pets in a large UK birth cohort study.

The aim of this study was to use the Avon Longitudinal Study of Parents and Children (ALSPAC) to describe
pet ownership during adolescence in terms of prevalence and predictors, and to compare to findings from the same co- hort during childhood.

Objectives are as follows:
(1) Describe the prevalence of the ownership of different pet types, and how these change throughout childhood and adolescence, from infancy up to age 18 years.
(2) Identify and describe the potential confounding factors associated with ownership of each pet type in adolescence at age 13 years. This age was chosen for examination as it marks the beginning of adolescence and is a period of great change in
terms of pubertal, cognitive and socio-emotional development. In addition, this age group was ideal in

At each age, participants were asked to recall whether they had any pets in their household and if so, how many pets they had of each type. Pet type included cats, dogs, rabbits, rodents (mice, hamster, gerbil, etc.), birds (budgerigar, parrot, etc.), fish, tortoises/turtles and horses. Horse ownership had not been recorded in the childhood (0-10 years) pet ownership dataset.

## Method

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a UK prospective birth cohort study that has been described in detail elsewhere [49]. Briefly, 14,541 pregnant women were recruited with expected deliv- ery dates between 1st April 1991 and 31st December 1992. Of the 13,978 singletons/twins alive at 1 year, a small number of participants withdrew consent ( $n=24$ ) leaving a starting sample of 13,954 . Data were collected from pregnancy onwards using postal questionnaires, clinic assessments, biological samples, linkage to routine information, abstraction from medical records and envir- onmental monitoring. The study website contains a searchable dictionary of all the available data (http://
www.bris.ac.uk/alspac/researchers/data-access/data-dic- tionary/). Ethical approval was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees; the participants provided written informed consent. As ethical approval and con- sent was sought as part of the data collection process for ALSPAC, and as this study analyses retrospective data, no ethical approval or consent was specifically required for the present study.

Pet ownership was reported by the mothers of 13,557 chil- dren during gestation, caregivers of 7800 children by age 10 years, and by 3098 adolescents at age 18 years for ages $11-18$ years. The pet ownership data from gestation up to age 10 years has been previously analysed and described in detail [37]. In addition, age 7 pet ownership data were collected retrospectively to assess the accuracy of participants' recall.
age which can be used to assess pet ownership patterns over time. For example, for dog ownership, clusters were formed for whether participants always, never or some- times owned a dog or up to age 11, 13,15 and 18 years.

Potential risk factors and confounding variables (including concurrent ownership of other pets) were exam- ined for association with ownership of each pet type at the earliest time point available for adolescence, which is 13 years. This was deemed a suitable age to compare to childhood pet ownership at age 7 , as it was predicted that the ownership of certain pet types is likely to de- crease in later adolescence. Socio-demographic variables included gender, ethnicity of the child, number of people in household, presence of an older sibling, maternal and paternal education and social class, maternal age at de- livery, whether the mother had pets as a child, and house type (See Table 1). These variables were chosen to match the potential confounders that were used in the childhood models [37]. The variables were entered into multivariable logistic regressions modelling the self- reported ownership of each specific pet type at child age 13 years. A model was not built for tortoises/turtles due to low frequency of ownership of these pets.

To address the problem of partial non-response among confounders, missing data were imputed using multivariate imputation by chained equations (MICE) [50]. These in- cluded number of people in household, presence of an older sibling, maternal education, paternal education, ma- ternal social class, paternal social class, maternal age at de- livery, mother had pets as a child and house type (detached, semidetached, end terrace, terraced, flat).

A large difference in sample sizes between ages 13 and 7 , even after multiple imputation, made direct comparison of samples challenging because observed differences could re- sult from sample attrition or non-response, rather than age (non-respondents in

ALSPAC are likely to differ in terms of socio-economic status [49]). Therefore, inferences from imputed models are not presented. In different approach, a comparison was made by rerunning the age 7 models only for those participants who had provided data at age 13 , ef- fectively using the same sample. These complete case models were compared to the original age 7 models (with the exception of horse ownership as this data was not avail- able at age 7). Not all of the predictors identified at 7 years of age were statistically significant at 13 years (with the ex- ception of gender and concurrent pet ownership), although generally speaking, when examining ORs and 95\% CIs, trends pointed in the same direction. It is important to note that these predictors of pet ownership may vary due to dif- ferences in sample size. Furthermore, a second comparison was made for the 13 year old models; children excluded from the study due to non-response were compared on key characteristics from those who were included in the final sample at age 13 years (Table 3).

Table 1 Potential confounders, method and time of data collection, and level of analysis
Variable Method and time of data collection Levels

| Ownership of a Cat, Dog, Rabbit, Rodent, Bird, Fish, | Collected re |
| :--- | :--- |
| Tortoise/turtles and Horse ownership | 18 years |

Gender Medical records at birth Male or female
Ethnicity of child Carer questionnaire at 140 White, mixed, Asian, black, other. Collapsed to 'white' months (11 years)

Number of people in household Derived from mother's questionnaire at 122 months ( 10 years)

Presence of an older sibling Derived from mother's questionnaire (child based) at 18 months and 'other'

3, 4, 5+

Maternal education Mother's questionnaire at 32
weeks gestation. Highest level indicated
CSE or no qualification (lowest),
Paternal education Mother's questionnaire at 32 vocational, O level, A level, degree (highest)
weeks gestation. Highest level indicated
Maternal social class Derived from mother's questionnaire at 32 weeks gestation (occupation)

Paternal social class Derived from mother's questionnaire at 32 weeks gestation (occupation)

CSE or no qualification (lowest), vocational, O level, A level, degree (highest)

Professional (highest), Managerial and technical, Skilled: non-manual,

Skilled: manual, Partly skilled, Unskilled (lowest)
Professional (highest), Managerial and technical, Skilled: non-manual,

Skilled: manual, Partly skilled, Unskilled (lowest)

Maternal age at delivery Clinical records Continuous (years)
OR < 21 years, 21-30 years, > 30 years Mother had pets as a child Mother's questionnaire at 33 months No, not at all; Yes, part of time; Yes, always

House type Derived from mother's questionnaire Detached, semi-detached, end terrace, terraced, at 122 months ( 10 years) flat/room in someone else's house/other

Step-wise backwards elimination, using the likelihood ratio, was used to manually remove variables from each model. Variables remained in the model if there was good evidence for an association ( $P<0.05$ ) or if removal re- sulted in substantial change to the effect of other variables ( $10 \%$ or greater). As two-way interaction terms between the variable 'mother owned pets as a child' and other pre-dictor variables were tested at age 7 [37], this was repeated at age 13, as a reasonable assumption that mother's pet ownership history may continue to influence adolescent pet ownership. The final models were confirmed with stepwise forward addition. The fit of the model was assessed using the Hosmer-Lemeshow statistic.

## Results

Pet ownership trends during childhood and adolescence During gestation, 58\% of mothers reported owning a pet. Family pet ownership of all types changed across childhood and adolescence (Fig. 1). By age 10 years, pet ownership had risen to $74 \%$, cat ownership was $31 \%$ and dog owner- ship was $26 \%$. There was an increase over time in the fre- quency of ownership of fish, rodents and rabbits until age 11 years. Thereafter, pet ownership of all pet types other than cats and dogs declined. By age 18 years, pet ownership stayed reasonably constant at 72\%, and dog ownership had risen to $37 \%$. Cats were the most commonly reported pet
up to age 15 years; dogs were the most common pet type among older adolescents. This is not consistent with na- tionwide data, where cat and dog ownership was reported to be equal from 2008 to 2012 [51].

Using two-step cluster analysis, clusters emerged from pet ownership up to ages 11, 13, 15 and 18. Including data up to age 11, age 15 and 18 years, only two pet ownership clusters were identified, subsequently termed: sometimes owned a pet; and always owned a pet (Fig. 2). When con- sidering data from all years up to age 13, three pet owner- ship clusters were identified: never owned a pet; sometimes owned a pet; and always owned a pet (Fig. 2).

There is an increased interest in researching the health benefits of dog ownership, perhaps due to a higher level of interaction and reciprocation in comparison to other pets. Therefore process was repeated for history of dog ownership. Dog ownership up to 11, 13 and 15 years formed two clusters: never owned a dog; and sometimes owned a dog (Fig. 2). Dog ownership up to 18 years formed 3 clusters: never owned a dog; sometimes owned a dog; and always owned a dog (Fig. 2).

Because cat and dog ownership was the most frequently reported, using two-step cluster analysis, further clusters were identified at each age for: own dog only; owns cat only; owns both dog and cat; owns neither dog nor cat (Fig. $\underline{3}$ ). With the use of these clusters, it will be possible to

separate out the effects of dog and cat ownership in future research.

Characteristics of sample at 13 years old
A comparison for the characteristics of the study children with reported pet ownership status at ages 7 and 13 years
are described in Table 2. At age 13, a higher proportion of the sample are female, and have a higher maternal and pa- ternal education in comparison to age 7 (Table 2). The characteristics of the study children at age 13 years are compared to the excluded children with no pet ownership data at age 13 years in Table 3. The excluded sample were


Fig. 2 Two-step cluster analysis in SPSS to identify ownership length of pet-ownership types


Fig. 3 Two-step cluster analysis in SPSS tosegregate reported dog-ownership from cat-ownership
more likely to be male, with a lower maternal and paternal education (Table $\underline{3}$ ).

Multivariable models for age 13 data
The results presented in the tables are data derived from multiple imputation. Complete-case analyses for all models were identical.

## Cat ownership

The final multivariable model of cat ownership at 13 years is presented in Table 4, alongside univariable data for comparison. Participants were more likely to own a cat if they owned fish, more likely if they were female and if maternal age at delivery was older (> 30 years). Participants with maternal pet ownership history (sometimes or always) were more likely to own a cat compared to children whose mothers did not own pets during childhood. The HosmerLemeshow statistic was high (0.77), suggesting good model fit.

## Dog ownership

The final multivariable model of dog ownership at 13 years is presented in Table $\underline{5}$, alongside univariable results for comparison. Participants were more likely to own a dog if they also owned a bird, fish or horse. Participants with an older sibling were more likely to report owning a dog. The older the mother was at delivery, the less likely the child was to report living with a dog. The Hosmer-Lemeshow statistic was high (0.83), suggesting good model fit.

## Rabbit ownership

The Hosmer-Lemeshow statistic for the rabbit model was low (0.22), suggesting a poor model fit. It is difficult to deter- mine why the model was a poor fit, we suggest it could be due to additional unknown confounding variables which have not been included in the model. The final multivariable
model of rabbit ownership at 13 years is presented in Table 6, alongside univariable results for comparison. Partic- ipants were more likely to report owning a rabbit if they also owned a rodent, fish, horse and were female. Those with maternal education at degree level were less likely to own a rabbit. Participants who had mothers who sometimes and always owned pets as a child were also more likely to own a rabbit than if their mothers never owned pets as a child.

## Rodent ownership

The final multivariable model of rodent ownership at 13 years is presented in Table 7, alongside univariable re- sults for comparison. Participants were more likely to re- port owning a rodent if they: owned a rabbit, fish, were female, had higher numbers of people living in the household, their mother sometimes owned pets as a child. Participants were less likely to report owning a ro- dent if they had older siblings and a lower maternal edu-cation. The Hosmer-Lemeshow statistic was high (0.92), suggesting good model fit.

## Bird ownership

The final multivariable model of bird ownership at 13 years is presented in Table 8, alongside univariable results for comparison. Participants were more likely to have a bird if they also owned a fish or horse. Likelihood of owning a bird decreased with increasing maternal education level, and was highest in skilled manual, and part-skilled paternal occupations.

## Fish ownership

Model is not presented as according to the HosmerLemeshow statistic (0.005), it was not a good fit for the data.

Table 2 Characteristics of the study children at ages 7 and 13 years with a reported ownership of any pets

| Variable | Level | Age 7 | Age 13 |
| :---: | :---: | :---: | :---: |
|  |  | $(n=8331)$ | $(n=2332)$ |
|  |  | Number (\%) | Number (\%) |
| Gender | Male | 4312 (52) | 751 (32) |
|  | Female | 4019 (48) | 1580 (68) |
| Ethnicity | White | 6068 (97) | 1868 (97) |
|  | Non-white | 422 (3) | 50 (3) |
| Number of people in household | 3 | 1233 (15) | 323 (15) |
|  | 4 | 4168 (50) | 1138 (51) |
|  | 5+ | 2904 (35) | 774 (34) |
| Presence of an older sibling at 18 months | Yes | 4323 (54) | 1140 (51) |
|  | No | 3636 (46) | 1095 (49) |
| Maternal education | CSE or no qualification (lowest) | 1631 (21) | 222 (10) |
|  | Vocational | 710 (9) | 166 (7) |
|  | O level | 2873 (35) | 722 (32) |
|  | A level | 2102 (26) | 647 (29) |
|  | Degree (highest) | 1269 (16) | 478 (21) |
| Paternal education | CSE or no qualification (lowest) | 1631 (21) | 366 (16) |
|  | Vocational | 639 (8) | 165 (7) |
|  | O level | 1711 (22) | 451 (20) |
|  | A level | 2199 (28) | 645 (29) |
|  | Degree (highest) | 1683 (21) | 608 (27) |
| Maternal social class | Professional (highest) | 478 (7) | 189 (9) |


|  | Managerial and technical | 2365 (34) | 814 (36) |
| :---: | :---: | :---: | :---: |
|  | Skilled: non-manual | 2957 (43) | 892 (40) |
|  | Skilled: manual | 467 (7) | 131 (6) |
|  | Partly skilled | 550 (8) | 176 (8) |
|  | Unskilled (lowest) | 116 (2) | 33 (2) |
| Paternal social class | Professional (highest) | 941 (13) | 344 (15) |
|  | Managerial and technical | 2667 (36) | 839 (38) |
|  | Skilled: non-manual | 858 (12) | 274 (12) |
|  | Skilled: manual | 2154 (29) | 574 (26) |
|  | Partly skilled | 603 (8) | 167 (8) |
|  | Unskilled (lowest) | 189 (3) | 37 (2) |
| Maternal age at delivery | < 21 years | 303 (4) | 56 (3) |
|  | 21-30 years | 5043 (61) | 1292 (58) |
|  | > 30 years | 2985 (36) | 887 (40) |
| Mother had pets as a child | No, not at all | 743 (10) | 196 (9) |
|  | Yes, part of time | 3517 (46) | 994 (45) |
|  | Yes, always | 3365 (44) | 1045 (47) |
| House type | Detached | 2443 (29) | 764 (34) |
|  | Semi-detached | 3086 (27) | 801 (36) |
|  | End terrace | 771 (9) | 198 (9) |
|  | Terraced | 1652 (20) | 396 (18) |
|  | Flat/room in someone else's house/other | 336 (4) | 76 (3) |

Table 3 Characteristics of the study children at age 13 years in comparison to excluded children at age 13 years (with no pet ownership data due to non-response)
$\left.\left.\begin{array}{llll}\hline & \text { Level } & \begin{array}{l}\text { Excluded Study } \\ \text { Children } \\ (n=4120)\end{array} & \begin{array}{l}\text { Included study } \\ \text { children }\end{array} \\ & & (n=2332)\end{array}\right] \begin{array}{ll}\text { Number (\%) }\end{array}\right)$

|  | Degree (highest) | 584 (15) | 608 (27) |
| :---: | :---: | :---: | :---: |
| Maternal social class | Professional (highest) | 167 (5) | 189 (9) |
|  | Managerial and technical | 1069 (32) | 814 (36) |
|  | Skilled: non-manual | 1490 (44) | 892 (40) |
|  | Skilled: manual | 250 (7) | 131 (6) |
|  | Partly skilled | 313 (9) | 176 (8) |
|  | Unskilled (lowest) | 73 (2) | 33 (2) |
| Paternal social class | Professional (highest) | 350 (10) | 344 (15) |
|  | Managerial and technical | 1202 (33) | 839 (38) |
|  | Skilled: non-manual | 389 (11) | 274 (12) |
|  | Skilled: manual | 1211 (34) | 574 (26) |
|  | Partly skilled | 339 (9) | 167 (8) |
|  | Unskilled (lowest) | 120 (3) | 37 (2) |
| Maternal age at delivery | < 21 years | 174 (4) | 56 (3) |
|  | 21-30 years | 2596 (63) | 1292 (58) |
|  | > 30 years | 1350 (33) | 887 (40) |
| Mother had pets as a child | No, not at all | 256 (7) | 196 (9) |
|  | Yes, part of time | 1574 (43) | 994 (45) |
|  | Yes, always | 1862 (50) | 1045 (47) |
| House type | Detached | 1073 (26) | 764 (34) |
|  | Semi-detached | 1586 (39) | 801 (36) |
|  | End terrace | 403 (10) | 198 (9) |
|  | Terraced | 871 (21) | 396 (18) |
|  | Flat/room in someone else's house/other | 170 (4) | 76 (3) |

Table 4 Multivariable binary logistic regression model of cat ownership at 13 years among children who reported any pet
ownership


Hosmer-Lemeshow statistic $=0.77, n=2923$

## Horse ownership

The final multivariable model of horse ownership at 13 years is presented in Table $\underline{9}$, alongside univariable re- sults for comparison. Participants were more likely

Table 5 Multivariable binary logistic regression model of dog ownership at 13 years

| Variable adjusted mod |  |  | Univariable result | ult (una | djusted) | Final |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | model | OR 95\%CI P | P | OR | 95\% Cl |
| P |  |  |  |  |  |  |
| Bird |  |  |  |  |  |  |
| No | 1 | 1 | 1 |  |  |  |
| Yes |  | . 53 | 1.81-3.52 < | < 0.001 | 12.12 | 1.47- |
| 3.0 |  | 0.001 |  |  |  |  |
| Fish |  |  |  |  |  |  |
| No |  | 1 |  | 1 |  |  |
| Yes regard to |  |  | 1.19-1.71>0.001 | 1.29 | 1.06-1.57 | 0.009 |
|  |  | cat and | d dog ownership. |  |  |  |
| It wals previously observed that family pet ownership in $\begin{array}{llllll}\text { Yes } & 10.32 & 6.43-16.55 & <0.001 & 10.43 & 6.34-17.18\end{array}$ |  |  |  |  |  |  |

Participants living in a semi-detached and terraced house were less likely to own a horse (in comparison to living in a detached house). The Hosmer-Lemeshow statistic was very high, (0.92) suggesting good model fit.

## Discussion

This paper describes patterns of pet ownership data in the ALSPAC cohort from 11 to 18 years, and presents multivariable models of pet ownership at 13 years of age to determine what confounding factors are important to take into account in future HAl studies. Consistent with the childhood findings, we find similar factors contribut- ing to the ownership of different pet types in adoles- cence. Interestingly, the interaction effects observed in childhood [37] were not present in the adolescent data,
particularly the interaction between maternal pet ownership in childhood and maternal or paternal education in creased during childhood (up to age 10 years) [37], and was expected to continue on this trajectory. However, in the present study, pet ownership peaked at age 11 for all

No 1 1

Yes $1.36 \quad 1.15-\quad<0.0011 .501 .26-\quad<0.001$ types except cats and dogs, which slightly increased. $1.59 \quad 1.79$ The

Maternal age at delivery largest decrease was in the ownership of small pets (rab-
bits, fish and rodents) which likely explains the descent in

| $<21$ yrs 1 |  | $<0.001$ | 1 |  | $<0.001$ |
| ---: | :--- | :--- | :--- | :--- | :--- |
| $21-30$ yrs | 0.46 | $0.29-0.73$ | 0.001 | 0.44 | $0.27-0.72$ |$<0.001$

Hosmer-Lemeshow statistic $=0.83, n=2922$
pet ownership as a whole in adolescence. types stayed fairly constant. These findings consistent with reports on pet-ownership a adolescents in Great Britain [43].

| Variable Un | result | (unadjusted) | Final adjusted model |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | OR | 95\%CI | P |  | OR | 95\%CI | P |
| Rodent |  |  |  |  |  |  |  |
| No | 1 |  |  |  | 1 |  |  |
| Yes | 2.23 | 1.80-2.77 | < 0.001 |  | 1.98 | 1.58-2.48 | < 0.001 |
| Fish |  |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |  |
| Yes | 1.82 | 1.46-2.28 | < 0.001 | 1.60 |  | 1.26-2.02 | < 0.001 |
| Horse |  |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |  |
| Yes | 2.20 | 1.43-3.39 | $<0.001$ | 1.92 |  | 1.22-3.01 | 0.005 |
| Gender |  |  |  |  |  |  |  |
| Male | 1 |  |  | 1 |  |  |  |
| Female | 1.69 | 1.35-2.12 | < 0.001 | 1.53 |  | 1.21-1.94 | < 0.001 |
| Maternal Education |  |  |  |  |  |  |  |
| CSE/None | 1 |  | 0.002 | 1 |  |  | 0.014 |
| Vocational | 0.59 | 0.35-1.04 | 0.052 | 0.61 |  | 0.35-1.04 | 0.68 |
| O Level | 0.90 | 0.64-1.28 | 0.582 | 0.94 |  | 0.66-1.35 | 0.750 |
| A Level | 0.86 | 0.60-1.23 | 0.393 | 0.89 |  | 0.62-1.28 | 0.544 |
| Degree | 0.53 | 0.35-0.78 | 0.001 | 0.56 |  | 0.37-0.84 | 0.005 |
| Mother had pets as a child |  |  |  |  |  |  |  |
| No, not at all | 1 |  | 0.004 | 1 |  |  | 0.023 |
| Yes, part of the time | 1.71 | 1.10-2.64 | 0.016 | 1.70 |  | 1.09-2.64 | 0.019 |


| Yes, always | 1.96 | $1.27-3.03$ | 0.002 | 1.70 | $1.109-2.64$ | 0.018 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |

Hosmer-Lemeshow statistic $=0.22, n=2656$

Our findings are similar to research suggesting that marginally higher levels of pet ownership exist in middle childhood (between 8 and 12-years-old) [39, 52, 53] compared to infancy and adolescence. In ALSPAC, cat ownership remained reasonably constant from ages 11 to 18 years; dog ownership increased and overtook cats as the most common pet. This is consistent with other data from UK [36, 38, $\underline{54}, \underline{55}]$ and English, Scottish, and

Welsh households [36, 42, 56]. Other research has also found small mammal ownership to decrease, but dog ownership to increase throughout adolescence [43]. In a study examining the socio-demographics of pet owner- ship among adolescents in Great Britain [43], 15-year- old ( $\mathrm{OR}=1.146, p<0.001$ ) and 13 -yearold ( $O R=1.240, p=0.021$ ) adolescents were significantly more likely than 11-year-old adolescents to own dogs, and less likely to own fish, reptiles, or amphibians ( $\mathrm{OR}=0.629, p<0.001$ ) and small mammals ( $O R=0.630, p<0.001$ ). Interest- ingly, in ALSPAC dog ownership did not follow a linear trend across childhood; in infancy and young childhood, dog ownership declined, suggesting families were more likely to acquire a dog once the youngest child in the family reaches middle childhood. This supports findings
that dogs are more common in households with older children [38].

Among ALSPAC children, owning one type of small pet was commonly associated with owning another type. However, no evidence was found for an association with dog ownership and cat ownership, and vice versa, similar to childhood [37]. This is consistent with other null find- ings on joint cat and dog ownership [55], but is at odds with studies in the UK and Ireland that do find associa- tions [34, 36, 57]. Dog ownership among ALSPAC chil- dren at age 13 years reflected the findings from 7 years
[37] in terms of concurrent bird and fish ownership. At age 13, those who owned a horse were also more likely to own a dog. This finding is consistent with observations from other studies [38]. However, in ALSPAC we cannot discuss about trends with earlier ages because at age 7, horse ownership was not queried as a separate pet category.

In contrast to findings at 7 years, there was no relationship between cat or dog ownership and education level of the mother or the father at age 13. This also contrasts with other studies which showed that cat owners had higher [36] and lower [41] education levels

Table 7 Multivariable binary logistic regression model of rodent ownership at 13 years
Variable Univariable result (unadjusted) Final adjusted model

|  | OR | 95\%CI | P | $\overline{O R}$ | 95\%CI | P |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Rabbit |  |  |  |  |  |  |
| No | 1 |  |  | 1 |  |  |
| Yes | 2.23 | 1.80-2.77 | < 0.001 | 1.78 | 1.39-2.31 | < 0.001 |

Fish

| No | 1 |  |  | 1 |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Yes | 1.92 | $1.58-2.32$ | $<0.001$ | 1.94 | $1.56-2.42$ | $<0.001$ |

Gender

| Male | 1 |  |  | 1 |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Female | 2.01 | $1.66-2.43$ | $<0.001$ | 2.12 | $1.79-2.63$ | $<0.001$ |

Number of people in household

| 3 | 1 |  | 0.005 | 1 |  | 0.018 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 4 | 1.37 | $1.04-1.83$ | 0.028 | 1.42 | $1.04-1.95$ | 0.027 |
| $5+$ | 1.65 | $1.22-2.26$ | 0.002 | 1.62 | $1.16-2.26$ | 0.005 |

Older sibling at 18 months

| No | 1 |  |  | 1 |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Yes | 0.912 | $0.76-1.09$ | 0.305 | 0.75 | $0.66-0.97$ | 0.005 |  |
| Maternal education |  |  |  |  |  | 0.037 |  |
| CSE/None | 1 |  | 0.29 | 1 |  | $0.46-1.13$ | 0.035 |
| Vocational | 0.70 | $0.46-1.08$ | 0.113 | 0.57 | $0.56-1.05$ | 0.004 |  |


| A Level | 0.85 | $0.63-1.16$ | 0.312 | 0.71 | $0.66-1.26$ | 0.56 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Degree | 0.87 | $0.43-1.19$ | 0.403 | 0.77 | $0.73-1.41$ | 0.163 |

Mother pets as a child

| No, not at all | 1 |  | 0.001 | 1 | 0.029 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Yes, part of time | 1.04 | $0.76-1.44$ | 0.792 | 1.03 | $0.73-1.44$ | 0.013 |
| Yes, always | 1.44 | $1.04-2.01$ | 0.030 | 1.37 | $0.97-1.94$ | 0.742 |

Hosmer-Lemeshow statistic $=0.92, n=2863$
than those without cats, and that dog ownership decreased as owners' education increased [34, 36, 41]. According to other research, adolescents were more likely to report having pet dogs if their parents were employed [43], while those with a medium family affluence level were less likely to own a cat than those with a low family affluence level [43]. Associations between dog ownership and lower social class [34] or family affluence [43] have been previously reported. The present study did not find any association between dog ownership and paternal or maternal social class at adolescence, as it had for childhood [37]. Rabbit, rodent and bird ownership models at age 13 identified similar predictors as those obtained at age 7, in terms of education and social class. Likelihood of owning a bird decreased with higher maternal education, and was highest in skilled manual, and partskilled paternal occupations at both ages. In a previous
study, adolescents were less likely to own birds if their family had a medium or higher family affluence level than adolescents with low family affluence level [43].

Previous pet ownership is related to current and future pet ownership [58, 59]. At age 7 years, bird ownership was the only pet type not affected by whether the mother owned pets as a child; this changed at age 13 years, where both dog ownership and horse ownership were also not affected by whether the mother owned pets as a child. Horse ownership at age 13 cannot be compared to ownership at age 7 years, as it was not mea- sured on previous occasions. The finding that at adoles- cence dog ownership was not explained by mothers' previous pet ownership could be due to greater partici- pation of the adolescent in the decision to obtain a pet, thus reducing the influence of maternal pet ownership history. However, for horse ownership it can be argued that financial considerations may depend on the parent,

| Variable | Univari result able (unadjusted) |  |  |  | Final adjusted model |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | OR | 95\%CI | P |  | OR | 95\%CI | P |
| Fish |  |  |  |  |  |  |  |
| No | 1 |  |  |  | 1 |  |  |
| Yes | 2.34 | 1.66-3.30 | < 0.001 |  | 2.29 | 1.60-3.28 | < 0.001 |
| Horse |  |  |  |  |  |  |  |
| No | 1 |  |  |  | 1 |  |  |
| Yes | 3.79 | 2.19-6.54 | < 0.001 |  | 3.68 | 2.07-6.53 | < 0.001 |
| Maternal education |  |  |  |  |  |  |  |
| CSE/None | 1 |  | < 0.001 | 1 |  |  | 0.006 |
| Vocational | 0.41 | 0.18-0.92 | 0.031 | 0.39 |  | 0.16-0.90 | 0.028 |
| O Level | 0.50 | 0.31-0.81 | 0.005 | 0.54 |  | 0.32-0.86 | 0.016 |
| A Level | 0.48 | 0.29-0.80 | 0.005 | 0.632 |  | 0.37-1.07 | 0.09 |
| Degree | 0.17 | 0.08-0.35 | < 0.001 | 0.26 |  | 0.12-0.55 | 0.001 |
| Paternal Social Class |  |  |  |  |  |  |  |
| Professional | 1 |  | < 0.001 | 1 |  |  | 0.003 |
| Managerial and technical | 1.16 | 0.58-2.29 | 0.674 | 0.96 |  | 0.48-1.94 | 0.899 |
| skilled non-manual | 1.12 | 0.49-2.57 | 0.785 | 0.86 |  | 0.37-1.99 | 0.730 |
| skilled manual | 2.65 | 1.42-4.94 | 0.002 | 1.92 |  | 1.01-4.03 | 0.060 |
| part skilled | 3.92 | 1.91-8.07 | < 0.001 | 2.72 |  | 1.23-5.87 | 0.010 |
| unskilled | 2.45 | 0.57-10.54 | 0.222 | 1.40 |  | 0.31-5.64 | 0.66 |

and therefore the decision to obtain a horse is likely more complex. At age 13 years, maternal pet ownership did predict rabbit ownership, as had been the case at age 7 years. One limitation of our data is that we do not know the individual pet types the mother had owned as
a child, and no qualitative data was collected on reason- ing to own a particular type of pet, therefore, any inter- pretation relies on speculation.

Findings differed slightly between the 7 and 13-year models in terms of maternal age at delivery. At age 7,

Table 9 Multivariable binary logistic regression model of horse ownership at 13 years

| Variable | Univariable result (unadjusted) Final adjusted model |  |  |  | OR | 95\%CI | P |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | OR | 95\%CI | P |  |  |  |  |
| Dog |  |  |  |  |  |  |  |
| No | 1 |  |  |  | 1 |  |  |
| Yes | 10.32 | 6.43-16.55 | < 0.001 |  | 10.43 | 6.36-17.10 | < 0.001 |
| Rabbit |  |  |  |  |  |  |  |
| No | 1 |  |  |  | 1 |  |  |
| Yes | 2.20 | 1.43-3.39 | < 0.001 |  | 1.37 | 0.79-2.37 | 0.006 |
| Gender |  |  |  |  |  |  |  |
| Male | 1 |  |  |  | 1 |  |  |
| Female 3.01 |  | 1.81-.5.02 | < 0.001 | 3.15 |  | 1.82-5.45 | < 0.001 |
| House Type |  |  |  |  |  |  |  |
| Detached | 1 |  | 0.002 | 1 |  |  | 0.004 |
| Semi-detached | 0.57 | 0.36-0.91 | 0.019 | 0.57 |  | 0.35-0.94 | 0.027 |
| End terrace | 0.62 | 0.29-1.32 | 0.214 | 0.62 |  | 0.28-1.35 | 0.235 |
| Terraced | 0.32 | 0.15-0.66 | . 002 | 0.33 |  | 0.15-0.69 | 0.003 |

Hosmer-Lemeshow statistic $=0.92 n=2866$
maternal age at delivery was independently associated with dog and rabbit ownership, with likelihood of ownership decreasing as maternal age increased. At age 13 years, maternal age at delivery was inversely associated with the likelihood of dog ownership, whereas it was positively associated with cat owner- ship. Westgarth et al. (2010) [37] concluded these as- sociations were not likely due to socio-economic differences between mothers who give birth when they are older or younger, as socioeconomic differences were also included in the model.

In the present study, the number of people in the house- hold was only positively associated with rodent ownership at age 13. Larger household size has also been associated with dog ownership in the UK [36, 38], and in ALSPAC children [37], but not in other studies [57]. Previous re- search also suggests that larger families are more likely to have companion animals [43, 60]. Why this differs at ado- lescence is not clear, but may be due to the difference in sample size. Research regarding pet ownership and num- bers of siblings is inconsistent [19, 39, 42, 44, 46, 61].

In addition to family size, being the youngest sibling may be an explanatory factor. At age 7 years, the pres- ence of an older sibling was an independent predictor of family ownership of dogs, rodents, birds and fish. At age 13 years, there is only evidence of an association between the presence of older siblings and the likelihood of dog or rodent ownership. Other research has suggested that youths with younger siblings own fewer pets than those without younger or any siblings [39]. However, the ALSPAC findings are difficult to dissect because, overall dog ownership increases whereas rodent ownership de- clines across adolescence, and yet their association with sibling age is similar.

The associations with gender and pet type at age 13 years were identical to the models at age 7; females were more likely to own cats, rabbits, and rodents. In addition, females were more likely to own horses. These findings are consistent with other studies on cats [34, 36, 42, 57], rodents and horses [42]; still
other studies found no gender differences [ $24, \underline{43}, \underline{44}]$. It has been suggested that girls may influence their parents to own certain types of pets [37]. We have difficulty inferring the influence of gender on family pet ownership, as family structures are likely to have both sexes [ $35,39,43$ ], and more than one attribute of the child and/or the family affects the decision to get a pet.

At age 13 years, house type was only associated with horse ownership. This is at difference with the models at age 7 years where house type was associated with both dog and rabbit ownership. Westgarth et al. [37] sug- gested this could be explained by family reasoning that dogs and rabbits are perceived to require more outdoor
space than other pet types, which could also explain the reasoning for horses. Although maternal education and social class were not significant in the final model, socio- economic status (SES) should not be discarded as a po- tential influence for horse ownership as house type is a measure of SES.

At age 7 years, ethnicity other than 'white' was associ ated with a lower likelihood of owning a cat or rodent [37]. However, at age 13 years, ethnicity is not related to any pet type. This is at odds with finding that adoles- cents were more likely to report owning cats if they were white compared with non-white adolescents [43]. Other research finds ethnicity to be the single most important predictor of pet ownership, with white adolescents being more likely to own any types of pets than non-white ad- olescents (Mixed, Asian, Black, and adolescents from other ethnicities) [43]. This is supported by other studies in adolescents [44] and young adults [62].

The lack of association in the ALSPAC cohort at age 13 years may be due to insufficient power. In the ALSPAC dataset the prevalence of ethnic minorities is relatively low [49].

This study has some limitations. First, the accuracy of retrospective recall of pet ownership could be questioned. However, recall accuracy has been tested for age 7 , when it was compared to data provided prospectively by caregivers on previous occasions. We found a high level of consistency between caregiverreported and youth- recalled pet ownership ( $P$ < 0.0001 ). Secondly, there may be other confounding variables that were not considered in the models. Other potential confounders could be con-sidered, for example measures of family adversity. The present findings cannot be generalised to all populations of children and adolescents in the UK. Although the cohort was broadly representative of UK populations at baseline, attrition of participants over time lead to certain differences, for example in ethnicity and social class [49]. There were marked differences between
excluded and in- cluded study children at age 13; nonresponse participants were more likely to be male and from a lower socio- economic background. It is important to note this differ- ence when comparing findings to other UK pet ownership studies, or further afield. However, advantages of the ALSPAC dataset are numerous, and include a large sam- ple size, longitudinal data collection, and availability of a wide range of confounding factors for multivariable analysis.

Conclusions
Many children grow up with pets, therefore it is important to investigate any potential psychological and physical ben- efits of pet ownership to child health. Due to limitations in study design and data analysis of research published to date [11], it has been difficult to determine whether any of the
associations reported could be explained by residual con- founding. Using the ALSPAC birth cohort, we showed that in adolescence, a number of socioeconomic and demo- graphic factors are associated with the ownership of differ- ent pet types. Therefore, the relevant factors to specific pet types must be accounted for in data analysis of pet owner- ship and improved health outcomes. In our analyses, maternal age at delivery, maternal education, and family structure were commonly reported indicators of pet owner- ship, and are likely to have independent effects on child health and development. These factors are potential con-founders in public health research and must be accounted for in future HAI studies.

## Abbreviations

ALSPAC: Avon Longitudinal Study of Parents and Children; HAI: Human-Animal Interaction; MICE: Multiple Imputation of Chained Equations

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RP analysed the data and drafted the manuscript. Authors RC, NG, CJ, KK, KM and CW contributed to data interpretation, and drafting of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The data that support the findings of this study are available from ALSPAC but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of ALSPAC.

Ethics approval and consent to participate
Ethical approval for ALSPAC was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees; the participants provided written informed consent. As ethical approval and consent was sought as part of the data collection process for ALSPAC, and as this study analyses retrospective data, no ethical approval or consent was specifically required for the present study.

Consent for publication
Not applicable.

Authors' contributions

There are no financial competing interests to be declared. Author Carri Westgarth is a member of the editorial board (Associate Editor) of this journal, and played a role in the handling of this manuscript (see author contributions).

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## Appendix C: Complete Case analyses

Complete case analyses

Table 40. Complete case univariable and multivariable associations between pet ownership at age 8 and self-esteem Harter Self-perception profile subscales (scholastic competence and global self-worth) at age 8 .

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Scholastic Competence |  |  |  |  |  |
| Has any Pet | 3056 | 0.81 (0.71, 0.92) | 0.006* | 0.79 (0.65, 0.98) | 0.034* |
| Has Dog | 3057 | 0.79 (0.68, 0.92) | 0.002* | 0.89 (0.71, 1.11) | 0.299 |
| Has Cat | 3057 | 0.80 (0.71, 0.92) | 0.001* | 0.80 (0.66, 0.96) | 0.016* |
| Has other/miscellaneous pets | 3057 | 0.92 (0.81, 1.04) | 0.197 | 0.89 (0.74, 1.06) | 0.189 |


|  | Univariable |  |  | Multivariable |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Global self-worth | $N$ | OR $(95 \% C I)$ | $p$ | OR (95\% CI) | $p$ |
| Has any Pet | 3044 | $0.91(0.78,1.05)$ | 0.199 | $0.97(0.79,1.19)$ | 0.770 |
| Has Dog | 4045 | $0.97(0.83,1.14)$ | 0.747 | $0.89(0.71,1.14)$ | 0.380 |
| Has Cat | 3045 | $0.92(0.80,1.06)$ | 0.244 | $0.99(0.82,1.21)$ | 0.959 |
| Has other /miscellaneous pets | 3045 | $0.94(0.82,1.07)$ | 0.338 | $1.03(0.85,1.23)$ | 0.789 |
| *P $<05$ |  |  |  |  |  |

*P<. 05
Analyses adjusted for: sex, maternal depression measured at child age 8, maternal anxiety measured at child age 6 , overcrowding (child age 8), house type (child age 7), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, car ownership, older children living with child, developmental delay measured at child age 30 months old, IQ measured at child age 8 years (accounted for in scholastic competence only), stressful life events measured at child age 4 years and maternal bonding measured at child age 3 .

Table 41. Complete case univariable and multivariable associations between pet ownership at ages 7, 10 and 13 and separation anxiety, social anxiety and generalized anxiety disorder symptoms at ages 7, 10 and 13 years.

|  |  | Univariable |  | Multivariable |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Age |  | $N$ | OR $(95 \% C D)$ | $p$ | OR (95\% CI) | $p$ |
|  | Separation Anxiety |  |  |  |  |  |
| $\mathbf{7}$ | Has any Pet |  |  |  |  |  |
| $\mathbf{1 0}$ |  | 3671 | $1.01(0.82,1.24)$ | 0.945 | $1.14(0.84,1.56)$ | 0.397 |
| $\mathbf{1 3}$ |  | 3266 | $1.15(0.91,1.46)$ | 0.230 | $1.35(0.94,1.95)$ | 0.102 |
|  | Has Dog | 1416 | $1.24(0.69,2.20)$ | 0.465 | $1.39(0.59,3.21)$ | 0.447 |
| $\mathbf{7}$ |  |  |  |  |  |  |
| $\mathbf{1 0}$ |  | 3667 | $0.96(0.76,1.22)$ | 0.778 | $1.11(0.78,1.57)$ | 0.565 |
| $\mathbf{1 3}$ |  | 3265 | $1.11(0.88,1.39)$ | 0.376 | $1.08(0.75,1.56)$ | 0.684 |
|  |  | 1418 | $1.30(0.80,2.11)$ | 0.289 | $1.41(0.71,2.82)$ | 0.325 |


|  |  | Univariable |  | Multivariable |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Age |  | $N$ | OR $(95 \% C I)$ | $p$ | OR (95\% CI) |
| $\mathbf{7}$ | Has Cat |  |  |  |  |
| $\mathbf{1 0}$ |  | 3667 | $1.27(0.95,1.43)$ | 0.132 | $1.18(0.89,1.58)$ |
| $\mathbf{1 3}$ |  | 3265 | $1.22(0.98,1.50)$ | 0.069 | $1.06(0.77,1.46)$ |
|  | Has other/miscellaneous | 1419 | $1.57(0.98,2.50)$ | 0.059 | $1.43(0.75,2.75)$ |
| $\mathbf{7}$ | pets |  |  |  |  |
| $\mathbf{1 0}$ |  | 3667 | $1.04(0.86,1.26)$ | 0.688 |  |
| $\mathbf{1 3}$ |  | 3265 | $1.02(0.83,1.24)$ | 0.886 | $1.09(0.83,1.44)$ |


|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Age |  |  |  |  |  |
| Social Anxiety |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |
| 7 | 3963 | 1.28 (1.01, 1.62) | 0.040* | 1.42 (1.02, 1.08) | 0.037* |
| 10 | 3423 | 1.23 (0.97, 1.55) | 0.092 | 1.49 (1.04, 2.16) | 0.031* |
| 13 | 1543 | 1.44 (0.99, 2.09) | 0.056 | 1.06 (0.64, 1.77) | 0.813 |
| Has Dog |  |  |  |  |  |
| 7 | 3959 | 0.91 (0.70, 1.17) | 0.467 | 0.97 (0.66, 1.41) | 0.854 |
| 10 | 3422 | 1.04 (0.83, 1.30) | 0.724 | 1.09 (0.77, 1.58) | 0.609 |
| 13 | 1546 | 1.10 (0.80, 1.51) | 0.533 | 0.70 (0.42, 1.17) | 0.171 |
| Has Cat |  |  |  |  |  |
| 7 | 3959 | 1.18 (0.95, 1.46) | 0.131 | 0.99 (0.73, 1.35) | 0.963 |
| 10 | 3422 | 1.13 (0.91, 1.39) | 0.257 | 0.98 (0.72, 1.36) | 0.936 |
| 13 | 1547 | 1.08 (0.79, 1.47) | 0.627 | 0.95 (0.60, 1.49) | 0.813 |



|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Age |  |  |  |  |  |  |
| Has Cat |  |  |  |  |  |  |
| 7 |  | 3977 | 1.19 ( 0.99, 1.41) | 0.055 | 1.16 (0.91, 1.47) | 0.231 |
| 10 |  | 1558 | 1.25 (1.03, 1.51) | 0.022* | 1.38 (1.04, 1.82) | 0.026* |
| 13 |  | 682 | 1.14 (0.83, 1.55) | 0.419 | 1.07 (0.69, 1.64) | 0.773 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 7 |  | 3977 | 1.07 (0.91, 1.27) | 0.379 | 1.12 (0.89, 1.41) | 0.351 |
| 10 |  | 1558 | 1.05 (0.87, 1.26) | 0.632 | 1.01 (0.77, 1.33) | 0.924 |
| 13 |  | 680 | 1.05 (0.78, 1.42) | 0.735 | 0.95 (0.63, 1.44) | 0.807 |

Analyses adjusted for: sex, maternal depression measured at child age 8 and 11 years, maternal anxiety measured at child age 6 and 11 years, overcrowding (child age 7, 8 and 10 years), house type (child age 7 and 10 years), highest parental social class, maternal education, maternal age
at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at child age 3, 9 and 11 years and maternal bonding measured at child age 3 years

Table 42. Complete case univariable and multivariable associations between pet ownership at ages 7,10 and 13 years and depressive symptoms at ages 7, 10 and 13 years

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
|  |  |  |  |  |  |
| 7 | 3952 | 1.07 (0.91, 1.26) | 0.391 | 1.04 (0.84, 1.29) | 0.712 |
| 10 | 3069 | 0.96 (0.72, 1.18) | 0.789 | 0.65 (0.43, 0.99) | 0.048* |
| 13 | 1366 | 1.30 (0.92, 1.84) | 0.126 | 0.79 (0.50, 1.26) | 0.330 |
|  |  |  |  |  |  |
| 7 | 3949 | 1.07 (0.90, 1.27) | 0.406 | 1.09 (0.85, 1.40) | 0.511 |
| 10 | 3068 | 0.98 (0.73, 1.32) | 0.932 | 1.10 (0.68, 1.79) | 0.690 |
| 13 | 1369 | 1.12 (0.83, 1.51) | 0.447 | 0.65 (0.40, 1.06) | 0.082 |
|  |  |  |  |  |  |
| 7 | 3949 | 1.12 (0.96, 1.31) | 0.129 | 1.06 (0.86, 1.31) | 0.570 |
| 10 | 3068 | 1.02 (0.78, 1.34) | 0.868 | 0.46 (0.28, 0.77) | 0.003* |
| 13 | 1370 | 1.16 (0.87, 1.55) | 0.302 | 0.83 (0.55, 1.26) | 0.387 |


|  | Univariable |  |  |  | Multivariable |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Age | $N$ | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |  |
|  |  |  |  |  |  |  |
| $\mathbf{7}$ | Has other/miscellaneous pets |  |  |  |  |  |
| $\mathbf{1 0}$ |  | 3949 | $1.03(0.89,1.18)$ | 0.673 | $1.05(0.86,1.28)$ | 0.658 |
| $\mathbf{1 3}$ |  | 3068 | $1.84(0.84,1.39)$ | 0.532 | $0.78(0.52,1.17)$ | 0.229 |

*P<. 05
Analyses adjusted for: sex, maternal depression measured at child age 8 and 11 years, maternal anxiety measured at child age 6 and 11 years, overcrowding (child age 7, 8 and 10 years), house type (child age 7 and 10 years), highest parental social class, maternal education, maternal age at delivery, financial difficulties, home ownership status, and car ownership, developmental delay measured at child age 30 months, older children living with child, stressful life events at child age 3, 9 and 11 years and maternal bonding measured at child age 3 years

Table 43. Complete case univariable and multivariable associations between pet ownership at ages 3 and 11 years and behavioural difficulties and ages 3 and 11 years

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Emotional difficulties |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |
| 3 | 7173 | 0.94 (0.86, 1.02) | 0.127 | 0.95 (0.87, 1.04) | 0.265 |
| 11 | 2057 | 1.17 (0.86, 1.58) | 0.307 | 0.98 (0.71, 1.34) | 0.886 |
| Has Dog |  |  |  |  |  |
| 3 | 7169 | 0.97 (0.88, 1.08) | 0.627 | 0.97 (0.87, 1.08) | 0.545 |
| 11 | 2060 | 1.16 (0.89, 1.51) | 0.258 | 1.08 (0.82, 1.42) | 0.586 |
| Has Cat |  |  |  |  |  |
| 3 | 7169 | 0.95 (0.87, 1.05) | 0.326 | 0.96 (0.86, 1.05) | 0.359 |
| 11 | 2061 | 1.09 (0.86, 1.41) | 0.459 | 0.99 (0.76, 1.28) | 0.925 |


|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Has other/miscellaneous pets |  |  |  |  |  |
| 3 | 7169 | 0.89 (0.82, 0.98) | 0.017* | 0.92 (0.84, 1.02) | 0.097 |
| 11 | 2060 | 1.03 (0.81, 1.31) | 0.799 | 0.91 (0.71, 1.17) | 0.479 |
| Hyperactivity |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |
| 3 | 7173 | 1.05 (0.96, 1.15) | 0.278 | 1.11 (0.94, 1.31) | 0.229 |
| 11 | 2056 | 1.12 (0.78, 1.60) | 0.535 | 1.28 (0.87, 1.86) | 0.207 |
| Has Dog |  |  |  |  |  |
| 3 | 7169 | 1.03 (0.92, 1.15) | 0.670 | 1.05 (0.93, 1.17) | 0.464 |
| 11 | 2059 | 1.18 (0.86, 1.60) | 0.309 | 1.22 (0.88, 1.67) | 0.231 |
| Has Cat |  |  |  |  |  |
| 3 | 7169 | 1.09 (0.98, 1.20) | 0.095 | 1.12 (1.01, 1.24) | 0.037* |
| 11 | 2060 | 1.19 (0.88, 1.60) | 0.243 | 1.21 (0.89, 1.65) | 0.221 |


|  |  | Univariable |  |  |  | Multivariable |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |  |
| Has other/miscellaneous pets |  |  |  |  |  |  |  |
| $\mathbf{1 1}$ |  | 7169 | $0.96(0.87,1.06)$ | 0.396 | $1.00(0.91,1.11)$ | 0.954 |  |



|  |  | Univariable |  |  |  | Multivariable |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | $\mathrm{OR}(95 \% \mathrm{Cl})$ | $p$ | OR (95\% Cl) | $p$ |  |
| $\mathbf{1 1}$ | Peer Problems | Has any Pet | 2057 | $0.93(0.72,1.20)$ | 0.574 | $0.93(0.71,1.22)$ |  |
|  | Has Dog | 2060 | $1.15(0.91,1.45)$ | 0.233 | $1.16(0.91,1.49)$ | 0.593 |  |
|  | Has Cat | 2061 | $1.19(0.96,1.49)$ | 0.113 | $1.17(0.93,1.47)$ | 0.192 |  |
|  | Has other/miscellaneous pets | 2060 | $0.73(0.59,0.91)$ | $0.004^{*}$ | $0.72(0.57,0.89)$ | $0.004^{*}$ |  |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
| Prosocial |  |  |  |  |  |  |
| Has any Pet |  |  |  |  |  |  |
| 3 |  | 7173 | 0.93 (0.85, 1.01) | 0.098 | 0.95 (0.86, 1.04) | 0.261 |
| 11 |  | 2058 | 0.84 (0.57, 1.23) | 0.371 | 0.91 (0.61, 1.37) | 0.656 |
| Has Dog |  |  |  |  |  |  |
| 3 |  | 7169 | 0.89 (0.79, 0.99) | 0.033* | 0.89 (0.79, 1.01) | 0.068 |
| 11 |  | 2061 | 1.20 (0.84, 1.72) | 0.309 | 1.37 (0.94, 1.99) | 0.103 |
| Has Cat |  |  |  |  |  |  |
| 3 |  | 7169 | 1.01 (0.91, 1.11) | 0.885 | 1.02 (0.92, 1.13) | 0.737 |
| 11 |  | 2062 | 0.96 (0.67, 1.36) | 0.803 | 0.95 (0.66, 1.37) | 0.795 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 3 |  | 7169 | 0.87 (0.79, 0.96) | 0.004* | 0.88 (0.79, 0.97) | 0.012* |
| 11 |  | 2061 | 0.76 (0.55, 1.06) | 0.109 | 0.80 (0.57, 1.13) | 0.202 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | OR (95\% CI) | $p$ | OR (95\% CI) | $p$ |
|  | Total Behavioural Difficulties |  |  |  |  |  |
|  | Has any Pet |  |  |  |  |  |
| 3 |  | 7173 | 1.04 (0.95, 1.13) | 0.435 | 1.07 (0.97, 1.17) | 0.167 |
| 11 |  | 2058 | 1.23 (0.84, 1.79) | 0.282 | 1.15 (0.77, 1.72) | 0.506 |
|  | Has Dog |  |  |  |  |  |
| 3 |  | 7169 | 1.04 (0.94, 1.16) | 0.465 | 1.05 (0.93, 1.17) | 0.450 |
| 11 |  | 2061 | 1.33 (0.97, 1.82) | 0.079 | 1.29 (0.92, 1.80) | 0.141 |
|  | Has Cat |  |  |  |  |  |
| 3 |  | 7169 | 1.06 (0.96, 1.16) | 0.251 | 1.07 (0.97, 1.19) | 0.181 |
| 11 |  | 2062 | 1.29 (0.96, 1.75) | 0.090 | 1.21 (0.88, 1.66) | 0.242 |
|  | Has other/miscellaneous pets |  |  |  |  |  |
| 3 |  | 7169 | 0.95 (0.87, 1.04) | 0.294 | 0.98 (0.88, 1.08) | 0.615 |
| 11 |  | 2061 | 0.79 (0.59, 1.06) | 0.116 | 0.73 (0.53, 0.99) | 0.044* |

Analyses adjusted for: sex, birthweight, maternal depression measured at child age 2 and 11 years, maternal anxiety measured at child age 2 and 11 years, overcrowding (child age 2 and 10 years), highest parental social class, maternal education, maternal age at delivery, family income,
housing defects, financial difficulties, home ownership status, car ownership, developmental delay measured at child age 30 months, child temperament at 2 years, older children living with child, stressful life events at child age 2 and 11 years and maternal bonding measured at child age 3 years

Table 44. Complete case univariable and multivariable associations between pet ownership at ages 3 and 11, and prosocial behaviour at ages 3 and 11 years

|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Has any Pet |  |  |  |  |  |
| 3 | 7173 | 0.17 (0.00, 0.34) | 0.048* | 0.09 (-0.05, 0.23) | 0.197 |
| 11 | 2142 | -0.12 (-0.28, 0.04) | 0.150 | -0.22 (-0.37, -0.07) | 0.004* |
| Has Dog |  |  |  |  |  |
| 3 | 7169 | 0.25 (0.04, 0.46) | 0.021* | 0.24 (0.06, 0.41) | 0.008* |
| 11 | 2145 | -0.06 (-0.21, 0.09) | 0.471 | -0.11 (-0.25, 0.03) | 0.117 |
| Has Cat |  |  |  |  |  |
| 3 | 7169 | -0.02 (-0.20, 0.16) | 0.835 | -0.04 (-0.19, 0.11) | 0.623 |
| 11 | 2146 | -0.09 (-0.23, 0.06) | 0.235 | -0.12 (-0.25, 0.01) | 0.065 |


|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Has other/miscellaneous pets |  |  |  |  |  |
| 3 | 7169 | 0.27 (0.09, 0.45) | 0.003* | 0.18 (0.03, 0.33) | 0.021* |
| 11 | 2145 | -0.01 (-0.14, 0.13) | 0.945 | -0.08 (-0.20, 0.05) | 0.222 |

Analyses adjusted for: sex, birthweight, maternal depression measured at child age 2 and 11 years, maternal anxiety measured at child age 2 and 11 years, overcrowding (child age 2 and 10 years), highest parental social class, maternal education, maternal age at delivery, family income, housing defects, financial difficulties, home ownership status, car ownership, developmental delay measured at child age 30 months, child temperament at 2 years, older children living with child, stressful life events at child age 2 and 11 years and maternal bonding measured at child age 3 years

Table 45. Complete case univariable and multivariable associations between pet ownership at ages 8,10 and 11 , and attention, impulsivity and memory tasks


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
|  | Has other/miscellaneous pets |  |  |  |  |  |
| 8 |  | 3748 | $-0.01(-0.12,0.11)$ | 0.924 | $0.04(-0.08,0.16)$ | 0.471 |
| 11 |  | 1642 | -0.04 (-0.14, 0.06) | 0.412 | 0.06 (-0.05, 0.16) | 0.273 |
|  | Attentional Switching (Dual Task) |  |  |  |  |  |
|  | Has any Pet |  |  |  |  |  |
| 8 |  | 3429 | $0.74(-0.43,1.92)$ | 0.215 | 0.95 (-0.31, 2.21) | 0.139 |
| 11 |  | 1536 | $0.10(-0.29,0.48)$ | 0.615 | 0.35 (-0.09, 0.79) | 0.118 |
|  | Has Dog |  |  |  |  |  |
| 8 |  | 3429 | $0.72(-0.55,1.99)$ | 0.264 | 0.67 (-0.70, 2.03) | 0.339 |
| 11 |  | 1538 | 0.47 (0.11, 0.83) | 0.010* | 0.57 (0.16, 0.98) | 0.006* |
|  | Has Cat |  |  |  |  |  |
| 8 |  | 3429 | 0.45 (-0.67, 1.56) | 0.436 | 0.24 (-0.94, 1.42) | 0.688 |
| 11 |  | 1539 | -0.04 (-0.37, 0.29) | 0.819 | 0.06 (-0.32, 0.43) | 0.767 |


|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Has other/miscellaneous pets |  |  |  |  |  |
| 8 | 3429 | 0.19 (-0.84, 1.23) | 0.707 | 0.61 (-0.50, 1.71) | 0.284 |
| 11 | 1538 | -0.01 (-0.33, 0.31) | 0.954 | $0.08(-0.28,0.43)$ | 0.676 |




|  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Age | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Impulsivity |  |  |  |  |  |
| 10 Stop-signal task 150ms delay |  |  |  |  |  |
| Has any Pet | 3302 | 0.08 (-0.14, 0.29) | 0.470 | 0.04 (-0.20, 0.28) | 0.759 |
| Has Dog | 3302 | -0.03 (-0.25, 0.19) | 0.804 | -0.18 (-0.44, 0.07) | 0.150 |
| Has Cat | 3302 | -0.01 (-0.22, 0.19) | 0.907 | -0.01 (-0.24, 0.21) | 0.920 |
| Has other/miscellaneous pets | 3302 | 0.17 (-0.02, 0.36) | 0.084 | 0.19 (-0.02, 0.39) | 0.083 |
| 10 Stop-signal task 250ms delay |  |  |  |  |  |
| Has any Pet | 3302 | 0.06 (-0.13, 0.25) | 0.525 | 0.03 (-0.18, 0.24) | 0.774 |
| Has Dog | 3302 | -0.14 (-0.33, 0.05) | 0.158 | -0.26 (-0.47, -0.04) | 0.020* |
| Has Cat | 3302 | -0.01 (-0.18, 0.17) | 0.939 | -0.01 (-0.20, 0.18) | 0.914 |
| Has other/miscellaneous pets | 3302 | 0.08 (-0.07, 0.25) | 0.288 | 0.11 (-0.07, 0.29) | 0.247 |


|  |  | Univariable |  |  |  |  |  | Multivariable |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | $\mathrm{B}(95 \% \mathrm{Cl})$ | $p$ | $\mathrm{~B}(95 \% \mathrm{Cl})$ | $p$ |  |  |  |
|  |  | Working Memory |  |  |  |  |  |  |  |
|  | Digit span task |  |  |  |  |  |  |  |  |
| $\mathbf{8}$ | Has any Pet | 3779 | $8.71(-1.58,19.00)$ | 0.097 | $8.64(-3.29,20.56)$ | 0.156 |  |  |  |
| $\mathbf{1 0}$ |  | 3317 | $9.77(-1.53,21.07)$ | 0.090 | $10.79(-2.89,24.48)$ | 0.122 |  |  |  |
|  | Has Dog |  |  |  |  |  |  |  |  |
| $\mathbf{8}$ |  | 3779 | $2.59(-8.56,13.74)$ | 0.649 | $0.49(-12.44,13.43)$ | 0.940 |  |  |  |
| $\mathbf{1 0}$ |  | 3317 | $3.16(-8.52,14.84)$ | 0.596 | $2.04(-12.21,16.30)$ | 0.779 |  |  |  |
|  | Has Cat |  |  |  |  |  |  |  |  |
| $\mathbf{8}$ |  | 3779 | $3.30(-6.53,13.12)$ | 0.511 | $2.71(-8.50,13.93)$ | 0.635 |  |  |  |
| $\mathbf{1 0}$ |  | 3317 | $3.63(-7.01,14.26)$ | 0.504 | $4.37(-8.38,17.12)$ | 0.502 |  |  |  |
|  | Has other/miscellaneous pets |  |  |  |  |  |  |  |  |
| $\mathbf{8}$ |  | 3779 | $4.91(-4.17,14.00)$ | 0.289 | $4.34(-6.17,14.86)$ | 0.418 |  |  |  |
| $\mathbf{1 0}$ |  | 3317 | $4.91(-4.95,14.77)$ | 0.329 | $5.49(-6.40,17.39)$ | 0.365 |  |  |  |

Analyses were adjusted for: sex, maternal depression at ages 8 and 11 years, maternal anxiety at ages 6 and 11 years, overcrowding at 8 and 10 years, house type at ages 7 and 10 years, highest parental social, maternal education, maternal age at delivery, home ownership status, family income and car ownership, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old, and mother-child bonding at child age 3 years

Table 46. Complete case Univariable and multivariable associations between pet ownership at ages 711 and 15, and KS1, KS2 and GCSE attainment

|  |  | Univariable linear association using continuous grade score |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| KS1 |  |  |  |  |  |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Reading |  |  |  |  |  |
| Has any Pet | 4166 | -0.20 (-0.28, -0.11) | <0.001* | $-0.09(-0.19,-0.01)$ | 0.029* |
| Has Dog | 4163 | -0.36 (-0.46, -0.27) | <0.001* | -0.19 (-0.28, -0.09) | <0.001* |
| Has Cat | 4163 | -0.05 (-0.14, 0.03) | 0.228 | $-0.03(-0.12,0.05)$ | 0.433 |
| Has other/miscellaneous pets | 4163 | -0.19 (-0.27, -0.12) | <0.001* | -0.12 (-0.19, -0.04) | 0..003* |
| Writing |  |  |  |  |  |
| Has any Pet | 4167 | -0.21 (-0.29, -0.14) | <0.001* | -0.16 (-0.23, -0.08) | <0.001* |
| Has Dog | 4164 | -0.31 (-0.39, -0.23) | <0.001* | -0.18 (-0.26, -0.09) | <0.001* |
| Has Cat | 4164 | -0.08 (-0.15, -0.01) | 0.035* | -0.07 (-0.14, 0.00) | 0.059 |
| Has other/miscellaneous pets | 4164 | -0.16 (-0.23, -0.09) | <0.001* | -0.13 (-0.19, -0.06) | <0.001* |


|  |  | Univariable linear association using continuous grade score |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| KS1 |  |  |  |  |  |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Maths |  |  |  |  |  |
| Has any Pet | 4165 | -0.16 (-0.24, -0.08) | <0.001* | -0.09 (-0.18, -0.02) | 0.021* |
| Has Dog | 4162 | -0.25 (-0.34, -0.16) | <0.001* | -0.16 (-0.25, -0.06) | 0.001* |
| Has Cat | 4162 | -0.11 (-0.18, -0.03) | 0.007* | -0.08 (-0.16, -0.00) | 0.043* |
| Has other/miscellaneous pets | 4162 | -0.12 (-0.19, -0.04) | 0.002* | -0.07 (-0.15, 0.00) | 0.054 |
| Total summary score |  |  |  |  |  |
| Has any Pet | 4166 | -0.58 (-0.79, -0.36) | <0.001* | -0.35 (-0.57, -0.14) | 0.002* |
| Has Dog | 4163 | -0.93 (-1.16, -0.69) | $<0.001^{*}$ | -0.51 (-0.76, -0.27) | $<0.001^{*}$ |
| Has Cat | 4163 | -0.24 (-0.45, -0.03) | 0.026* | -0.19 (-0.40, 0.02) | 0.078 |
| Has other/miscellaneous pets | 4163 | -0.49 (-0.68, -0.29) | <0.001* | -0.32 (-0.51, -0.12) | 0.001* |


| KS2 | Univariable |  | Multivariable |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Subject | N | $\mathrm{B}(95 \%$ | $C I)$ | $p$ | $\mathrm{~B}(95 \%$ |
| English |  |  |  | $p$ |  |
| Has any Pet | 1542 | $-0.08(-1.56,1.40)$ | 0.915 | $-0.35(-2.14,1.44)$ | 0.703 |
| Has Dog | 1545 | $-2.23(-3.61,-0.86)$ | $0.001^{*}$ | $-1.18(-2.88,0.52)$ | 0.173 |
| Has Cat | 1545 | $-1.17(-2.45,0.11)$ | 0.072 | $-1.22(-2.71,0.27)$ | 0.109 |
| Has other/miscellaneous pets | 1545 | $0.35(-0.86,1.56)$ | 0.565 | $-0.00(-1.44,1.43)$ | 0.999 |


| KS2 |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Maths |  |  |  |  |  |
| Has any Pet | 1536 | -2.48 (-4.41, -0.54) | 0.012* | -1.27 (-3.58, 1.03) | 0.278 |
| Has Dog | 1538 | -2.95 (-4.75, -1.14) | 0.001* | -1.84 (-4.02, 0.34) | 0.098 |
| Has Cat | 1538 | -2.39 (-4.07, -0.71) | 0.005* | -0.99 (-2.92, 0.92) | 0.308 |
| Has other/miscellaneous pets | 1538 | -0.38 (-1.98, 1.21) | 0.640 | -0.19 (-2.05, 1.66) | 0.839 |
| Science |  |  |  |  |  |
| Has any Pet | 1542 | -0.95-(2.00, 0.10) | 0.077 | 0.14 (-1.41, 1.14) | 0.836 |
| Has Dog | 1545 | -1.55 (-2.54, -0.58) | 0.002* | -0.50 (-1.71, 0.71) | 0.419 |
| Has Cat | 1545 | -1.48 (-2.39, -0.57) | 0.001* | -1.19 (-2.26, -0.14) | 0.027* |
| Has other/miscellaneous pets | 1545 | 0.08 (-0.78, 0.95) | 0.850 | 0.25 (-0.78, 1.27) | 0.640 |
| Total KS2 point score |  |  |  |  |  |
| Has any Pet | 306 | 0.47 (-2.37, 3.31) | 0.743 | 0.77 (-3.12, 4.66) | 0.697 |
| Has Dog | 307 | $-2.36(-5.05,0.32)$ | 0.084 | -2.68 (-6.59, 1.24) | 0.179 |
| Has Cat | 307 | $-1.54(-4.08,0.99)$ | 0.231 | -1.01 (-4.33, 2.32) | 0.552 |
| Has other/miscellaneous pets | 307 | 1.98 (-0.38, 4.34) | 0.100 | 1.12 (-2.08, 4.32) | 0.491 |


| GCSE |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| English |  |  |  |  |  |
| Has any Pet | 1556 | 0.83 (0.68, 0.99) | 0.048* | 0.77 (0.59, 0.99) | 0.047* |
| Has Dog | 1559 | 0.66 (0.55, 0.79) | <0.001* | 0.64 (0.49, 0.84) | 0.001* |
| Has Cat | 1559 | $0.94(0.78,1.12)$ | 0.467 | $0.84(0.65,1.07)$ | 0.165 |
| Has other/miscellaneous pets | 1560 | 0.79 (0.66, 0.94) | 0.009* | 0.86 (0.68, 1.09) | 0.218 |
| Maths |  |  |  |  |  |
| Has any Pet | 1504 | 0.80 (0.67, 0.97) | 0.024* | 0.84 (0.65, 1.09) | 0.181 |
| Has Dog | 1507 | 0.67 (0.56, 0.81) | <0.001* | 0.72 (0.56, 0.93) | 0.012* |
| Has Cat | 1507 | 0.83 (0.69, 0.99) | 0.040* | 0.77 (0.55, 1.09) | 0.138 |
| Has other/miscellaneous pets | 1506 | 0.93 (0.78, 1.10) | 0.399 | 0.76 (0.54, 1.07) | 0.119 |
| Biological Sciences |  |  |  |  |  |
| Has any Pet | 383 | 0.55 (0.37, 0.81) | 0.002* | 0.48 (0.28, 0.83) | 0.009* |
| Has Dog | 384 | 0.77 (0.54, 1.08) | 0.132 | 0.80 (0.48, 1.34) | 0.401 |
| Has Cat | 384 | 0.85 (0.59, 1.20) | 0.356 | 0.78 (0.47, 1.29) | 0.325 |
| Has other/miscellaneous pets | 384 | 0.53 (0.38, 0.75) | <0.001* | 0.49 (0.30, 0.78) | 0.002* |


| GCSE |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Subject | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Chemistry |  |  |  |  |  |
| Has any Pet | 377 | 0.50 (0.34, 0.74) | 0.001* | 0.35 (0.20, 0.62) | <0.001* |
| Has Dog | 378 | 0.73 (0.52, 1.04) | 0.084 | 0.65 (0.39, 1.07) | 0.089 |
| Has Cat | 378 | 0.76 (0.53, 1.07) | 0.116 | 0.68 (0.41, 1.13) | 0.136 |
| Has other/miscellaneous pets | 378 | 0.59 (0.42, 0.82) | 0.002* | 0.42 (0.26, 0.67) | <0.001* |
| Physics |  |  |  |  |  |
| Has any Pet | 375 | 0.59 (0.40, 0.87) | 0.007* | 0.62 (0.36, 1.05) | 0.073 |
| Has Dog | 376 | 0.85 (0.59, 1.21) | 0.377 | 0.84 (0.51, 1.39) | 0.494 |
| Has Cat | 376 | 0.85 (0.59, 1.20) | 0.349 | 0.79 (0.48, 1.31) | 0.360 |
| Has other/miscellaneous pets | 376 | 0.63 (0.45, 0.89) | 0.030* | 0.69 (0.44, 1.10) | 0.121 |


|  | Univariable |  |  | Multivariable |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Total number of GCSEs achieved | N | $\mathrm{B}(95 \% C I)$ | $p$ | $\mathrm{~B}(95 \% C I)$ | $p$ |
| $\mathbf{A}^{*}$-C |  |  |  |  |  |
| Has any Pet | 1570 | $0.89(0.72,1.09)$ | 0.249 | $0.99(0.73,1.34)$ | 0.958 |
| Has Dog | 1573 | $0.65(0.54,0.79)$ | $<0.001^{*}$ | $0.78(0.59,1.04)$ | 0.006 |
| Has Cat | 1573 | $1.06(0.88,1.29)$ | 0.527 | $1.05(0.79,1.39)$ | 0.738 |
| Has other/miscellaneous pets | 1574 | $0.89(0.75,1.07)$ | 0.224 | $0.92(0.70,1.20)$ | 0.537 |

Analyses were adjusted for: sex, maternal depression at ages 6,8 and 11 years, maternal anxiety at ages 6 and 11 years, overcrowding at 7 and 10 years, house type at ages 7 and 10 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership, school identifier, school type, birthweight, developmental delay, child temperament, older children living in the house, stressful life events at almost 4 years, 9 and 11 years old, and mother-child bonding at age 3

Table 47. Complete case Univariable and multivariable associations between pet ownership at ages 2 and 5, and language development scores

|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| Reynell Developmental Language Scale |  |  |  |  |  |  |
|  | Has any Pet |  |  |  |  |  |
| 2 |  | 511 | -1.17 (-2.47, 0.13) | 0.077 | -0.15 (-0.15, 1.16) | 0.826 |
| 5 |  | 298 | 0.39 (-0.35, 1.13) | 0.299 | 1.06 (0.16, 1.96) | 0.021* |
| Has Dog |  |  |  |  |  |  |
| 2 |  | 510 | -1.89 (-3.71, -0.07) | 0.041* | -1.20 (-2.96, 0.56) | 0.181 |
| 5 |  | 298 | -0.24 (-1.25, 0.77) | 0.646 | 0.72 (-0.52, 1.96) | 0.253 |
| Has Cat |  |  |  |  |  |  |
| 2 |  | 510 | $-0.78(-2.15,0.60)$ | 0.270 | -0.17 (-1.50, 1.17) | 0.808 |
| 5 |  | 298 | 0.27 (-0.53, 1.09) | 0.502 | 0.02 (-0.92, 0.95) | 0.972 |
| Has other/miscellaneous pets |  |  |  |  |  |  |
| 2 |  | 510 | -2.23 (-6.05, 1.58) | 0.251 | -3.39 (-6.90, 0.13) | 0.059 |
| 5 |  | 298 | 0.65 (-1.33, 2.63) | 0.520 | 1.41 (-0.71, 3.53) | 0.192 |


|  |  |  | Univariable |  | Multivariable |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | B (95\% CI) | $p$ | B (95\% CI) | $p$ |
| 2 | Total Communication Score |  |  |  |  |  |
|  | Has any Pet | 4316 | 1.31 (-1.33, 3.95) | 0.330 | 1.45 (-0.84, 3.73) | 0.216 |
|  | Has Dog | 4309 | -1.01 (-4.43, 2.42) | 0.565 | -1.98 (-4.92, 0.97) | 0.188 |
|  | Has Cat | 4311 | -0.89 (-3.77, 2.00) | 0.547 | 0.08 (-2.37, 2.53) | 0.949 |
|  | Has other/miscellaneous pets | 4311 | -2.76 (-10.81, 5.29) | 0.502 | 0.99 (-5.88, 7.87) | 0.777 |
| 2 | Vocabulary Score |  |  |  |  |  |
|  | Has any Pet | 4353 | 0.99 (-1.29, 3.28) | 0.395 | 1.35 (-0.71, 3.42) | 0.199 |
|  | Has Dog | 4346 | -0.79 (-3.75, 2.17) | 0.602 | -1.52 (-4.18, 1.13) | 0.261 |
|  | Has Cat | 4348 | -0.72 (-3.22, 1.78) | 0.572 | 0.02 (-2.19, 2.23) | 0.987 |
|  | Has other/miscellaneous pets | 4348 | -2.09 (-9.07, 4.88) | 0.556 | 0.71 (-5.49, 6.91) | 0.823 |
| 2 | Non-Verbal Communication Score |  |  |  |  |  |
|  | Has any Pet | 4340 | 0.22 (0.05, 0.39) | 0.014* | $0.14(-0.03,0.31)$ | 0.105 |
|  | Has Dog | 4333 | 0.08 (-0.14, 0.31) | 0.469 | $0.03(-0.19,0.25)$ | 0.780 |
|  | Has Cat | 4335 | 0.02 (-0.17, 0.21) | 0.823 | $0.04(-0.14,0.22)$ | 0.633 |
|  | Has other/miscellaneous pets | 4335 | -0.09 (-0.62, 0.44) | 0.731 | 0.30 (-0.20, 0.80) | 0.242 |


|  |  | Univariable |  |  |  | Multivariable |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Age |  | N | $\mathrm{B}(95 \% \mathrm{CI})$ | $p$ | $\mathrm{~B}(95 \% \mathrm{Cl})$ | $p$ |  |
| $\mathbf{2}$ | Social Development Score |  |  |  |  |  |  |
|  | Has any Pet | 4337 | $0.06(-0.24,0.36)$ | 0.687 | $0.05(-0.21,0.32)$ | 0.693 |  |
|  | Has Dog | 4330 | $-0.41(-0.79,-0.03)$ | $0.035^{*}$ | $-0.41(-0.75,-0.07)$ | $0.020^{*}$ |  |
|  | Has Cat | 4332 | $-0.03(-0.36,0.29)$ | 0.852 | $0.04(-0.24,0.32)$ | 0.796 |  |
|  | Has other/miscellaneous pets | 4332 | $0.25(-0.66,1.16)$ | 0.587 | $0.53(-0.28,1.33)$ | 0.199 |  |

Analyses were adjusted for: sex, ethnicity, maternal depression at almost 2 and 4 years, maternal anxiety at ages almost 2 and 4 years, overcrowding at 2 years, house type at ages 2 and 3 years, highest parental social class, maternal education, maternal age at delivery, home ownership status, family income and car ownership, birthweight, child has twin, child attended day care at 15 months, and 4 years, number of languages spoken in the home, developmental delay at 18 months, child temperament, older children living in the house, stressful life events at almost 2 and 4 years old and mother-child bonding at age 3 years


[^0]:    ${ }^{1}$. Introduction
    Childhood and adolescence are crucial life phases in their contribution to the quality of health, emotional well-being, learning and behaviour across the life span [1]. Relationships with others are fundamental contributors to child and adolescent development according to relationship psychology [2] and attachment theory [3]. Yet, studies of child development have largely been limited

