Abstract: Objective
To investigate the longitudinal association between pet ownership and children's social-emotional development.

Study design
Two time-points of data from the Longitudinal Study of Australian Children were analysed for children aged five (n=4242) and seven (n=4431). The Strengths and Difficulties Questionnaire (SDQ) measured children's social-emotional development. Pet ownership status and type (dog, cat, other) as well as sociodemographic and other confounders were collected. Longitudinal panel regression models were used.

Results
Overall, 27% of children had abnormal scores on one or more SDQ scales. By age seven 75% of children had pets with ownership highest in single-child households. Owning any type of pet was associated with decreased odds of abnormal scores for emotional symptoms (OR: 0.81; 95% CI: 0.67, 0.99), peer problems (OR 0.71; 95% CI: 0.60, 0.84) and prosocial behaviour (OR 0.70; 95% CI: 0.38, 0.70), compared with non-pet owners. Dog ownership was associated with decreased odds of abnormal scores on any of the SDQ scales (OR: 0.81; 95% CI: 0.71, 0.93). In longitudinal models cat only and dog only groups were associated with fewer emotional symptoms and peer problems, compared with non-pet owners.

Conclusions
Early school age is an important period for family pet acquisition. Children without siblings benefit most in terms of their prosocial behaviour. Pets may protect children from developing social-emotional problems and should be taken into account when assessing child development and school readiness.
There are no linked research data sets for this submission. The following reason is given:
The authors do not have permission to share data
25 November 2019

Professor Paul Graham Fisher
Associate Editor
Journal of Pediatrics

Dear Professor Fisher,

RE: Ms No. 20191788R1 “Pets associated with fewer peer problems and emotional symptoms, and better prosocial behavior: Findings from the Longitudinal Study of Australian Children”

We thank you for the opportunity to revise our manuscript as requested in your email on 4 November 2019. Below we have addressed the reviewer’s feedback in turn which has helped to further strengthen the manuscript. Edits to the manuscript are included in the revised version and indicated below specifically.

Reviewer #2:

1. Regarding the large proportion of the LSAC population having higher SES, thank you for clarifying that this is representative of the Australian population and that weighting of the sample corrects for deviations from representativeness. That is not the issue here and there was never a suggestion to eliminate from analysis those people who do not fit the higher SES categories. It is simply an observation as to whom the study findings can most confidently be applied to. This is not addressed in the discussion of the findings. The paragraph on strengths and limitations mentions that LSAC is a nationally representative sample, which is a strength, but there is no statement of the limitation that because the vast majority of the sample is high SES, the conclusions cannot be as easily generalized to the entire Australian population (renting a home and living in a metropolitan region were highly predictive of non-inclusion in the longitudinal analysis) and that future studies should address this gap. Highlighting this is critically important because SES is a strong predictor of behavior problems.
Thank you for clarifying this request. The limitations have been edited: ‘The Longitudinal Study of Australian Children is the highest quality source of population representative longitudinal child development data in Australia and can be regarded as one of the best in the world. However, care should be taken when extrapolating findings to those sectors of Australian society who were less well represented in the study, such as families living in metropolitan areas who were renting their home.’ (see page 15, paragraph 1).

2. Regarding the comparison of children included and excluded from analysis, it would be useful to readers if Table 2 in the appendix was included as an online supplemental table.

Table 2 from the previous response has been included as a supplemental table as requested.

3. Regarding clarifying that children contributed two data points to the longitudinal analysis—Pg 9 paragraph two states "children contributed up to two data points". "Up to" could mean one or two.

This has been edited for clarity: ‘All longitudinal models used data from two time points for each contributing child (n=3017). Data from children who contributed only one time point were not included in the analysis.’ (see page 9, paragraph 2).

4. Regarding the numbers in Figure 1. The sample size for the cross sectional analysis is 7883 but the sample size listed in Table 1 is 8673. Could you please clarify this discrepancy and present the characteristics of the children who are actually participating in the analyses that are being reported here, not the whole cohort?

The analyses in Table 1 (n=8673) are descriptive and thus include all participants with data for the variables of interest. Table 1 also provides important information about missing data. We think it could be misleading to only show the descriptive information for those without any missing data. Figure 1 shows the sample size with complete data included in the pooled cross-sectional regression models (n=7883). We defer to the Editor as to whether the descriptive characteristics of the sample should be presented differently.

5. Regarding the inclusion of "any pet" category in the analysis, please include the same justification in the methods section as is provided in the response to reviewers. Having this information directly in the paper would be really helpful.

This has been added: ‘A binary variable for any pet ownership (yes/no) was created to enable comparison with other studies that have not differentiated between pet types due to sample size issues or question specificity.’ (see page 7, last paragraph).
Reviewer #3:

Thank you for responding to all of the reviewers concerns. I believe that the manuscript has been strengthened and could provide a solid foundation for further research in this area. Although there are some remaining concerns about the methods and the relatively small number of data points for each child, you have adequately addressed those concerns in your discussion.

Thank you.

1. Two minor editorial changes:
   - MS p 6 line 6: the wording is awkward and tense does not agree. I would suggest writing: "...better suited to understanding the role..."
   - p14 line 12, remove the comma after "having"

These edits have been made.

We would like to thank the reviewers for providing the opportunity to further revise our manuscript and address the comments provided. We believe that by addressing these comments our manuscript has been further strengthened. Queries and correspondence related to this paper can be directed to Assoc/Prof Hayley Christian (hayley.christian@uwa.edu.au).

Yours sincerely,

Assoc/Prof Hayley Christian
25 November, 2019

Prof William F. Balistreri
Editor
The Journal of Pediatrics

Dear Prof Balistreri,

**RE: Re-submission of Ms. No. 20191788R1**

“Pets associated with fewer peer problems and emotional symptoms, and better prosocial behavior: Findings from the Longitudinal Study of Australian Children”

We thank you for the opportunity to revise our manuscript as requested in your email on 4 November 2019. We have addressed the reviewer’s feedback in turn which has helped to strengthen the manuscript. Edits to the manuscript are included in the revised version. Included in our revision is a point-by-point response to the issues raised by the two reviewers.

*The authors have no potential, perceived or real conflicts of interest relevant to this article to disclose.*

*There are no prior publications or submissions with any overlapping information, including studies and patients.*

Queries and correspondence related to this paper can be directed to Assoc/Prof Hayley Christian (hayley.christian@uwa.edu.au).

We look forward to hearing from you.

Yours sincerely

Associate Professor Hayley Christian
AUTHORSHIP AGREEMENT AND CONTRIBUTION

Please submit one (1) form signed by ALL authors

All submissions to The Journal of Pediatrics must adhere to and provide information in accordance with the International Committee of Medical Journal Editors’ (ICMJE) recommendations and guidelines pertaining to authorship criteria. Only individuals who fulfill the ICMJE’s conditions for authorship should be included in the author list. Individuals who have contributed to the study, but do not meet the requirements for authorship, should be included in the Acknowledgments section.

By signing this authorship agreement and contribution form, authors agree that

- The manuscript represents original work and there are no prior publications or submissions with overlapping information, OR
- Any prior publications with overlapping information, including studies and patients have been disclosed and a copy of the work(s) uploaded with this submission;
- The manuscript has not been and will not be submitted to any other journal while it is under consideration by The Journal of Pediatrics; and
- All conflicts of interest, real and perceived, and funding sources have been reported

Article title: Pets associated with fewer peer problems and emotional symptoms, and better prosocial behaviour

Date submitted: 2 August 2019

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Email:

I confirm that I am an author on the above mentioned manuscript, which is currently being submitted to The Journal of Pediatrics. My authorship contribution consisted of the following (note: authors must meet all four conditions):

1) Substantial contributions to the study, including (please mark all that are applicable):

☐ Conceptualization/design ☐ Funding acquisition
☐ Methodology ☐ Data curation
☐ Investigation ☐ Formal analysis
☐ Supervision/oversight ☐ Resources

2) Participation in the writing and/or revision, including:

☐ Writing – drafting the initial manuscript
☐ Writing – review or editing of the manuscript

3) I gave final approval of the version to be published

☐ Yes ☐ No

4) I agree to be accountable for all aspects of the work

☐ Yes ☐ No
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   - Yes  [ ]  No

4) I agree to be accountable for all aspects of the work
   - Yes  [ ]  No

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I confirm that I am an author on the above mentioned manuscript, which is currently being submitted to *The Journal of Pediatrics*. My authorship contribution consisted of the following (note: authors must meet all four conditions):

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   - No

Stephen R Zubrick  
1st August 2019

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   - [ ] Writing – review or editing of the manuscript

3) I gave final approval of the version to be published
   - [ ] Yes
   - [ ] No

4) I agree to be accountable for all aspects of the work
   - [ ] Yes
   - [ ] No
☐ Yes  ☐ No

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Date
Pets associated with fewer peer problems and emotional symptoms, and better prosocial behaviour: Findings from the Longitudinal Study of Australia Children

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**Short title:** Pets linked with better social-emotional development

**Funding source:** Australian National Heart Foundation Future Leader Fellowship (#100794 to HC); an Australian Research Council Centre of Excellence for Children and Families over the Life Course (CE140100027 to FM, RC and SZ). The Centre is administered by the Institute for Social Science at the University of Queensland, with nodes at the University of Western Australia, The University of Melbourne and the University of Sydney.

**Conflict of Interest Statement:** The authors have no potential, perceived or real conflicts of interest relevant to this article to disclose. HC and RC wrote the first draft of the manuscript.

**Keywords:** Pet, Child, Development, Social-emotional, Longitudinal

**Abbreviations:** SDQ, The Strengths and Difficulties Questionnaire
ABSTRACT

Objective
To investigate the longitudinal association between pet ownership and children’s social-emotional development.

Study design
Two time-points of data from the Longitudinal Study of Australian Children were analysed for children aged five (n=4242) and seven (n=4431). The Strengths and Difficulties Questionnaire (SDQ) measured children’s social-emotional development. Pet ownership status and type (dog, cat, other) as well as sociodemographic and other confounders were collected. Longitudinal panel regression models were used.

Results
Overall, 27% of children had abnormal scores on one or more SDQ scales. By age seven 75% of children had pets with ownership highest in single-child households. Owning any type of pet was associated with decreased odds of abnormal scores for emotional symptoms (OR: 0·81; 95% CI: 0·67, 0·99), peer problems (OR 0·71; 95% CI: 0·60, 0·84) and prosocial behaviour (OR 0·70; 95% CI: 0·38, 0·70), compared with non-pet owners. Dog ownership was associated with decreased odds of abnormal scores on any of the SDQ scales (OR: 0·81; 95% CI: 0·71, 0·93). In longitudinal models cat only and dog only groups were associated with fewer emotional symptoms and peer problems, compared with non-pet owners.

Conclusions
Early school age is an important period for family pet acquisition. Children without siblings benefit most in terms of their prosocial behaviour. Pets may protect children from developing social-emotional problems and should be taken into account when assessing child development and school readiness.
INTRODUCTION

Pet ownership is associated with a number of physical, mental and social health benefits in both adults\(^1\)\(^-\)\(^3\) and children.\(^2\) In adults, pet owners compared with non-owners are more physically active, have lower cardiovascular mortality, report fewer minor health problems, and greater levels of social support and sense of community.\(^4\)\(^-\)\(^7\) In children, pet ownership is associated with higher levels of physical activity, greater independent mobility and reduced likelihood of developing allergies.\(^2\)\(^,\)^8\(^,\)^9 There is some evidence to suggest that pet ownership is associated with better developmental outcomes in children. Pets may play a role in the social-emotional development of children, including higher self-esteem, autonomy, trust, pro-social behavior (sharing, helping, cooperating), empathy for others and decreased feelings of loneliness.\(^2\)\(^,\)^10 However, most studies to date are limited by methodological issues such as small and non-representative samples, a lack of adjustment for confounders and weak study designs.\(^10\)

There are a number of mechanisms through which pets may facilitate a child’s development. For example, pets, in particular dogs, facilitate increased physical activity and active play in children\(^11\) which has a number of mental health benefits.\(^12\) Pets may also provide a “social buffer” for their owners in situations of increased stress or anxiety.\(^13\) Importantly, the presence of pets in the household may teach children valuable life lessons, such as empathy towards others, the inevitability of death and, responsibility for other living things.\(^14\) These types of daily life lessons contribute towards children’s development enabling them to participate in social and civic life.

Most research on the benefits of human-animal interaction for children has focussed on children with health conditions and disorders such as autism spectrum disorder, ADHD and
allergies/asthma, with a paucity of evidence around the role of pets as companion animals (rather than service animals) in normal child social development. Although previous observational studies have reported a positive effect of pets on child developmental outcomes, many of these studies were unable to adequately control for strong socioeconomic confounders. Due to the cross-sectional design of these studies, no causal inferences could be made. Longitudinal studies are better suited to understanding the role of pets in a child’s development. The aim of this study was to: a) determine the prevalence of exposure to pet ownership amongst a large representative sample of Australian children from the Longitudinal Study of Australian Children (LSAC); b) investigate the association between pet ownership and children’s social-emotional development; and c) investigate if the relationship between pet ownership and children’s social-emotional development differed by sibling status.

METHODS:

Sample and data

Data from Growing Up in Australia: the Longitudinal Study of Australian Children (LSAC) were analysed. This prospective study used a two cohort cross-sequential design and in 2004 recruited 5107 children to the baby cohort (median age = 9 months, SD = 2.6 months) and 4983 children to the kindergarten cohort (median age = 4.75 years, SD = 2.6 months). The sampling method provided a representative sample of Australian children. A cross-sectional analysis of pet ownership and child outcomes was conducted using data pooled from wave two of the kindergarten cohort (2006) and wave four of the baby cohort (2010) (Figure 1; online). The median child age was 6.8 years (SD 3.2 months). Longitudinal analyses were performed using data for children from the kindergarten cohort from wave one (2004; median age 4.8) and wave two (2006; median age 6.8) (Figure 1; online). This study was exempt
from Human Research Ethics Committee approval as it involved secondary analysis of existing data.

Measures

Strengths and Difficulties Questionnaire

The Strengths and Difficulties Questionnaire (SDQ) is a behavioural screening tool for children aged 4 to 16 years that has good validity and reliability when compared to psychiatric diagnostic tools, and is in common use as a mental health indicator in population surveys of children. The questionnaire was completed by primary caregivers, who answered 25 items about their child’s behaviour in the previous 6 months. The questionnaire measures five scales; emotional symptoms, peer problems, hyperactivity, conduct problems, prosocial behaviour. The mean scale scores are calculated from items each rescaled to an integer between 0-10. The SDQ total difficulties score is the sum of four scales, excluding the prosocial scale. We hypothesised that the behaviours measured by each of the five scales may be affected differently by pet ownership and thus examined each of the five scales as separate outcomes. For each of the five SDQ scale scores and the total SDQ score, individuals were categorised using the SDQ group score categorisation of ‘normal’, ‘borderline’ and ‘abnormal’. The ‘normal’ and ‘borderline’ categories were combined to form binary variables that indicated whether the child was in the abnormal range for a particular behaviour (yes/no). A variable to indicate whether the child scored in the abnormal range for one or more of the five individual SDQ scales (yes/no) was also created.

Pet ownership status

For both cohorts, the first time-point pet ownership was collected was at wave 1 (Baby cohort= 0-1 years; Kindergarten cohort= 4-5 years) and the second time-point was at wave 2
for the kindergarten cohort and wave 4 for the baby cohort, when all children were 6-7 years old. A binary variable for any pet ownership (yes/no) was created to enable comparison with other studies that have not differentiated between pet types due to sample size issues or question specificity. Children were also assigned to one of five mutually exclusive categories of pet ownership (Dogs only, Cats only, Dogs and cats, Other type of pet only, No pets). Parents were asked ‘Do you have a dog/cat/other pets?’.

Adjustment variables
Chi-square tests (for categorical variables) and t-tests (for continuous variables) were conducted to assess whether known or potential socio-demographic confounders were associated with both pet ownership and SDQ outcomes. Variables that were statistically associated with both SDQ scores and pet ownership were included in all final models as adjustment variables: family type (one parent, couple, step/blended), younger siblings (yes/no), older siblings (yes/no), primary caregiver work status (full-time, part-time, unemployed, not in labour force), education (grade 10 secondary school; university degree), residing in rental property (yes/no), mental health of primary caregiver (Kessler-6 standardised score21), household income (standardised weekly income/person), neighbourhood disadvantage (standardised socio-economic index for areas (SEIFA) score).22

Statistical analysis
Descriptive analyses were undertaken to describe the socio-demographic characteristics of the pooled cohorts, the proportion of children ‘abnormal’ on each of the SDQ scales, types of pet ownership and pet acquisition in initially pet-free and dog-free households by sibling presence. Separate multiple logistic regression models were fitted to test for associations between type of pet owned and the odds of scoring in the abnormal range for each of the five
SDQ scales, total SDQ score and on any of the five SDQ scales. All models adjusted for the variables identified in the ‘Adjustment variables’ section previously. The reference group was ‘abnormal SDQ score’. To test whether the protective effect of pet ownership was larger in children without siblings, we fitted models again using a subsample of 689 children who did not have siblings. Due to the restricted sample size, only pet ownership status (yes/no) could be examined.

Longitudinal analyses were undertaken to test for an association between pet ownership type and children’s continuous SDQ scale scores (range 0 – 10) for sub-scales found to be significant in cross-sectional analyses (i.e., emotional symptoms, peer problems and prosocial behaviour). Within the kindergarten cohort only, longitudinal panel regression models were used to control for time-constant unobserved differences between children and their family context. To model between and within person effects within the longitudinal panel data, we used hybrid panel regression models\(^{23}\) implemented in STATA. All longitudinal models used data from two time points for each contributing child (n=3017). Data from children who contributed only one time point were not included in the analysis. Adjustment variables were the same as for those in the cross-sectional analyses.

**RESULTS:**

**Socio-demographic characteristics and social-emotional behaviour of sample**

Almost half of children were girls (49%), the mean age was 6.8 years, most (91%) had siblings and 82% lived in a couple family (Table 1; online). Three quarters of primary carers worked full or part-time, 33% had a university degree, 77% owned or were buying their house, 80% lived in an average-above average socio-economic area, and 14% reported psychological distress. The proportion of children categorised with abnormal scores across
the five SDQ scales ranged from 2.4% to 10.7%. Almost 27% of children had abnormal scores on one or more SDQ scales.

**Pet ownership**

In the baby cohort at 9 months old 64% of children had any type of pet in the household with 45% dog owners, 23% cat owners and 25% owning another type of pet only (Table 2). In the kindergarten cohort at 4-5 years, 68% of children had any type of pet in the household with 43% dog owners, 27% cat owners and 11% owning another type of pet only. At 6-7 years 75% of children were in a household that owned any type of pet, with 51% dog owners, 22% cat owners, and 12% the owner of another type of pet only. Overall, the prevalence of pet ownership increased as children aged. Between the ages of 0-1 and 6-7 years, any pet ownership rose by 11%. Between 4-5 years and 6-7 years, any pet ownership increased by 7%.

Pet acquisition was lowest in households where children had younger siblings and highest in households where children had no siblings (Table 3). Over 22% of children without siblings acquired a pet other than a dog or cat. Overall, one-quarter of families changed from being non-dog owners to dog owners during the follow up period. Dog acquisition was highest in households where children had older siblings (28%) and lowest in households where children had younger siblings (19%).

**Abnormal social-emotional behaviours by pet ownership status**

For children 6-7 years, compared to not owning a pet, owning any type of pet was associated with decreased odds of having an abnormal emotional symptoms score (OR: 0.81; 95% CI: 0.67, 0.99). (Table 4). However, when considering the type of pet owned, only cat ownership
was associated with decreased odds of having an abnormal emotional symptoms score (OR: 0.68; 95% CI: 0.49, 0.93). This was not quite statistically significant for dog ownership (OR: 0.82; 95% CI: 0.66, 1.02). Owning any type of pet was associated with decreased odds of having an abnormal peer problem score (OR 0.71; 95% CI: 0.60, 0.84), compared with non-pet owners. This relationship was consistent across different types of pet ownership (dog, cat, other pet). Owning any type of pet was associated with decreased odds of having an abnormal prosocial behaviour score (OR 0.70; 95% CI: 0.38, 0.70), compared with non-pet owners and this was also consistent across different types of pet ownership. Owning any type of pet was associated with increased odds of having an abnormal hyperactivity score (OR 1.25; 95% CI: 1.04, 1.50), compared with non-pet owners. In particular, owning a cat, compared with not owning any pets, was associated with increased odds of having an abnormal hyperactivity score (OR: 1.40; 95% CI: 1.08, 1.80). Pet ownership was not significantly associated with abnormal conduct problems scores or total SDQ scores. Owning a dog was associated with decreased odds of having an abnormal score on any of the SDQ scales (OR: 0.81; 95% CI: 0.71, 0.93).

Effect of siblings on abnormal social-emotional behaviours by pet ownership status

For children without any siblings, only the prosocial behaviour scale was significantly associated with pet ownership (Table 4). In single-child households, owning any type of pet compared with no pets was associated with decreased odds of having an abnormal score on the prosocial behaviour scale (OR 0.21; 95% CI: 0.07, 0.66).

Longitudinal relationship between social-emotional development and pet ownership

In longitudinal models cat only and dog only groups were associated with lower scores on the emotional symptoms and peer problems SDQ scales compared with children who did not
have a pet (Table 5). Cat owners compared with non-pet owners had a 0.28 lower score on the peer problems scale (95% CI: -0.40, -0.17). Dog only and other pet only groups had better scores on the prosocial behaviour scale, compared with non-pet owners (Dog only: \( \beta=0.22; \) 95% CI: 0.12, 0.33; Other pet only: \( \beta=0.15; \) 95% CI: 0.03, 0.27). For the emotional symptoms scale, the dog only effect appeared to be from between individuals rather than within person (i.e., individual change in dog ownership) change.

**DISCUSSION**

Findings from this study show that owning a household pet is associated with fewer social-emotional problems in young children, and this is consistent across pet types (i.e., dog, cat or other type of pet). Importantly, children were 20% less likely to have abnormal scores on any social-emotional development scale if they had a dog compared with no pets at all. These findings are in part supportive of other studies showing that children who have pets have higher empathy scores.\(^{24,25}\)

Our longitudinal results point to the need for more studies to investigate the possible causal links between pet ownership and child development. Findings across two time-points demonstrate the sustained average positive effect of pets on early child development. Compared with children with no pets, children with dogs or cats had fewer emotional symptoms and peer problems, and dog owners had better pro-social behaviour. To our knowledge, there has been only one other small longitudinal study (27 children 8-12 years) to investigate the relationship between young children’s social-emotional development and pet ownership. This study followed children for the first year after obtaining a dog to examine the impact of dog acquisition on family and child social interactions, child health, well-being and behaviour.\(^{26}\) Findings suggested that children’s behaviour improved (i.e., less ‘naughty’,
more co-operative) in the first month of acquisition compared to non-dog owning children, but there were no differences between the two groups at six and 12 month follow up. Our study is one of the first to examine pet ownership and social-emotional outcomes in children in a longitudinal context using a sample that is representative of the general population. Further prospective studies using large representative samples of children are required to confirm the long-term benefits of pet ownership (particularly dog and cat) as well as pet loss for children’s social-emotional development across childhood.

The magnitude of association between pet ownership and young children’s social-emotional development was found to be small, but positive. Pet ownership was associated with positive child social outcomes such as relationships with peers and the ability to form friendships and be well-liked. This was particularly evident for children without siblings. Interacting with other children including one’s siblings facilitates positive social behaviours and a family pet may provide a similar role to siblings in supporting a child’s social-emotional development. Pets may be beneficial for children without siblings who have less opportunities to interact with other children at home. Interacting with pets can help children learn about social concepts by mimicking the interactions that children have with other humans. Interacting positively with a pet increases confidence, reducing the fear of rejection in social interactions with other children. Pets can also facilitate social interactions between children. Furthermore, it appears that the social benefits of pets traverses the life course. In adults pet ownership is associated with higher social capital and sense of community (i.e., connections between individuals, their social networks and notions of trustworthiness) compared to not owning a pet.
Our findings highlight that the prevalence of pet ownership increases across the early years, increasing most rapidly at the time children enter full-time school. Between birth and a child entering full-time school, the rate of pet ownership increased by 11%. Half of households who did not own a dog when their child was 4-5 years had obtained one by the time their child was 6-7 years. Over three quarters of families owned a pet of any type by the time their child was 6-7 years, suggesting that interacting with pets is a normal part of growing up for most children. Similar pet ownership rates have been observed in a study of 8331 UK children from birth to age 10. Family pet ownership increased during childhood, increasing most rapidly at the time children entered full-time school (4-7 years) and by the age of seven, over 70% of families owned a pet. This highlights critical windows of opportunity for studying the intervention effect of pet acquisition as well as the long term effect of pets on child development across childhood. Future research should consider the health and developmental effect of pets on children and adolescents as they transition from primary to secondary school.

Finally, this study found that pet ownership was associated with poorer outcomes relating to a child’s attention span and ability to complete tasks (SDQ hyperactivity sub-scale). While controlling for known confounders, due to the cross-sectional observational design there is potential for residual confounding from uncontrolled socio-demographic factors. It is possible that parents of hyperactive children may have been more likely to acquire pets for their child rather than pet ownership causing children to be more hyperactive. To our knowledge the influence of pets on the hyperactivity behaviour of young children has not been investigated. However, there is some evidence to suggest the presence of animals can assist positively in maintaining attention in children. A theoretical review has suggested animal-assisted interventions may have calming, socialising and motivating effects in children with ADHD.
Due to these mixed findings and that children scoring ≥90th percentile on the hyperactivity sub-scale have been shown to be significantly more likely to be diagnosed with ADHD than other children\textsuperscript{32,33}, further research is warranted to better understand how pets influence children’s hyperactivity and social-emotional development.

This study was limited by having pet ownership status at only two time-points and within a small age range. A strength of this study was its large representative sample of children however, studies with more time-points are needed to tease out within person effects and determine the impact of the timing of pet acquisition (or loss) on child development. While we controlled for many socio-demographic factors related to pet ownership, data was not collected on the child’s relationship with and attachment to the pet which could mediate the relationship between pet ownership and child development.\textsuperscript{24} The Longitudinal Study of Australian Children is the highest quality source of population representative longitudinal child development data in Australia and can be regarded as one of the best in the world. However, care should be taken when extrapolating findings to those sectors of Australian society who were less well represented in the study, such as families living in metropolitan areas who were renting their home. Moreover, while representative of the Australian population, these findings may be less generalizable to the US or UK where there are lower rates of home ownership, which can prevent pet ownership due to the restrictions of having pets in rental properties. Similarly, country-specific differences in the proportion of two-parent households and parental employment may influence pet ownership rates.

In conclusion, by age seven, three quarters of children had a pet. The time children start formal schooling is an important period for family pet acquisition with the presence of other siblings in the household influencing the decision to obtain a pet and children without
siblings benefiting most in terms of their pro-social behaviour. Our results from cross-sectional and longitudinal analyses highlight that pets may protect children from developing peer relationship problems, emotional symptoms and deficits in prosocial behaviours. Given the positive effects of pets on early child development and the high proportion of families who have pets, it is possible that pets are an important mechanism to take into account when assessing child development and school readiness.\textsuperscript{34,35}

Acknowledgements

Ms Melissa Coci (MPH) and Pulan Bai (MPH) from the University of Western Australia provided administrative assistance.
REFERENCES


15. Department of Social Services AIoFS, the Australian Bureau of Statistics. *Growing Up in Australia, the Longitudinal Study of Australian Children* 2010.


Table 1. Characteristics of the pooled baby and kindergarten cohorts at the 6-7 years old follow-up \((n=8,673)\), Longitudinal Study of Australian Children.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child of female sex</td>
<td>48.7</td>
</tr>
<tr>
<td>Child’s age, years(^1)</td>
<td>6.82 (0.273)</td>
</tr>
<tr>
<td>Education level of primary carer</td>
<td></td>
</tr>
<tr>
<td>Completed Year 10 of secondary school</td>
<td>95.4</td>
</tr>
<tr>
<td>University qualification or higher</td>
<td>33.0</td>
</tr>
<tr>
<td>Work status of primary carer</td>
<td></td>
</tr>
<tr>
<td>Full-time (&gt; 30 hours)</td>
<td>25.8</td>
</tr>
<tr>
<td>Part-time (1 - 30 hours)</td>
<td>42.5</td>
</tr>
<tr>
<td>Unemployed/ not in labour force</td>
<td>31.6</td>
</tr>
<tr>
<td>Family type</td>
<td></td>
</tr>
<tr>
<td>Original couple family</td>
<td>82.2</td>
</tr>
<tr>
<td>One parent family</td>
<td>13.8</td>
</tr>
<tr>
<td>Step/ blended family</td>
<td>4.01</td>
</tr>
<tr>
<td>Siblings in household</td>
<td></td>
</tr>
<tr>
<td>No siblings</td>
<td>8.72</td>
</tr>
<tr>
<td>Younger siblings</td>
<td>52.1</td>
</tr>
<tr>
<td>Older siblings</td>
<td>57.7</td>
</tr>
<tr>
<td>Renting home</td>
<td>22.6</td>
</tr>
<tr>
<td>Psychological distress of primary carer-giver(^2)</td>
<td></td>
</tr>
<tr>
<td>High levels of psychological distress</td>
<td>11.1</td>
</tr>
<tr>
<td>Probable serious mental illness</td>
<td>2.52</td>
</tr>
<tr>
<td>Annual household income&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>$\leq 50,000$</td>
<td>24.0</td>
</tr>
<tr>
<td>$50,000 - 79,000$</td>
<td>26.0</td>
</tr>
<tr>
<td>$80,000 - 109,000$</td>
<td>23.0</td>
</tr>
<tr>
<td>$\geq 110,000$</td>
<td>27.0</td>
</tr>
<tr>
<td>SEIFA Advantage / Disadvantage</td>
<td></td>
</tr>
<tr>
<td>Below national average (-0.5 SD)</td>
<td>19.8</td>
</tr>
<tr>
<td>At national average</td>
<td>52.3</td>
</tr>
<tr>
<td>Above national average (+0.5 SD)</td>
<td>27.9</td>
</tr>
<tr>
<td>Abnormal on SDQ scale</td>
<td></td>
</tr>
<tr>
<td>Emotional symptoms</td>
<td>7.51</td>
</tr>
<tr>
<td>Peer problems</td>
<td>10.7</td>
</tr>
<tr>
<td>Prosocial behaviour</td>
<td>2.43</td>
</tr>
<tr>
<td>Hyperactivity</td>
<td>10.3</td>
</tr>
<tr>
<td>Conduct problems</td>
<td>9.74</td>
</tr>
<tr>
<td>Abnormal total SDQ score</td>
<td>6.62</td>
</tr>
<tr>
<td>Abnormal on any SDQ scale</td>
<td>26.7</td>
</tr>
</tbody>
</table>

<sup>1</sup> Value is expressed as mean (standard deviation).

<sup>2</sup> 158 missing observations (2%).

<sup>3</sup> 546 missing observations (7%).

* Missing data not reported when less than 1% of the total sample.
Table 2. Percentage of households with different types of pets at 0-1 years old, 4-5 years old and 6-7 years old by cohort, Longitudinal Study of Australian Children.

<table>
<thead>
<tr>
<th></th>
<th>Any pet (%)</th>
<th>Dog (%)</th>
<th>Cat (%)</th>
<th>Dog and cat (%)</th>
<th>Another type of pet (%)</th>
<th>Other pet only (%)</th>
<th>No pets (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby cohort (0-2 years old)</td>
<td>63.9</td>
<td>44.7</td>
<td>23.3</td>
<td>11.2</td>
<td>24.6</td>
<td>7.9</td>
<td>36.1</td>
</tr>
<tr>
<td>Kindergarten cohort (4-5 years old)</td>
<td>68.3</td>
<td>43.4</td>
<td>26.5</td>
<td>12.0</td>
<td>-</td>
<td>12.9</td>
<td>31.6</td>
</tr>
<tr>
<td>Both cohorts (6-7 years old)</td>
<td>75.1</td>
<td>51.2</td>
<td>22.4</td>
<td>11.6</td>
<td>-</td>
<td>12.2</td>
<td>24.9</td>
</tr>
</tbody>
</table>
Table 3. Pet acquisition between 4-5 years and 6-7 years in initially pet-free or dog-free households by sibling presence\(^1\), Longitudinal Study of Australian Children - kindergarten cohort.

<table>
<thead>
<tr>
<th></th>
<th>No siblings</th>
<th>Younger siblings only</th>
<th>Older siblings only</th>
<th>Younger and older siblings</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pet acquisition in non-pet owners(^2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog only</td>
<td>17·9</td>
<td>14·1</td>
<td>19·4</td>
<td>15·4</td>
<td>17·6</td>
</tr>
<tr>
<td>Cat only</td>
<td>7·59</td>
<td>4·95</td>
<td>7·74</td>
<td>8·63</td>
<td>6·73</td>
</tr>
<tr>
<td>Both a dog and cat</td>
<td>2·07</td>
<td>0·73</td>
<td>2·51</td>
<td>1·57</td>
<td>1·57</td>
</tr>
<tr>
<td>Another type of pet only</td>
<td>22·1</td>
<td>17·3</td>
<td>14·8</td>
<td>13·7</td>
<td>16·5</td>
</tr>
<tr>
<td>Remain non-pet owner</td>
<td>50·4</td>
<td>62·9</td>
<td>55·6</td>
<td>54·1</td>
<td>57·6</td>
</tr>
<tr>
<td><strong>Dog acquisition in non-dog owners(^3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog acquisition in non-dog owners(^3)</td>
<td>24·4</td>
<td>19·2</td>
<td>28·3</td>
<td>25·9</td>
<td>24·2</td>
</tr>
</tbody>
</table>

\(^1\) Children with siblings of the same age only were excluded due to small sample size (n=13)

\(^2\) 31.6% of kindergarten cohort families had no pet when the children were aged 4-5 years

\(^3\) 56.6% of kindergarten cohort families had no dog when the children were aged 4-5 years
Table 4. Adjusted odds ratios for abnormal scores on the strengths and difficulties questionnaire, Longitudinal Study of Australian Children.\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>All children (n=7883)</th>
<th>Children without siblings (n=689)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any pet</td>
<td>Dog</td>
</tr>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td><strong>Emotional symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any pet</td>
<td>0.81*</td>
<td>0.82</td>
</tr>
<tr>
<td>Dog</td>
<td>(0.67 to 0.99)</td>
<td>(0.66 to 1.02)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.71**</td>
<td>0.73**</td>
</tr>
<tr>
<td>Dog and cat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat</td>
<td>(0.60 to 0.84)</td>
<td>(0.61 to 0.88)</td>
</tr>
<tr>
<td>Other pet only</td>
<td>0.70**</td>
<td>0.44**</td>
</tr>
<tr>
<td>Total SDQ score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any pet</td>
<td>0.87</td>
<td>0.81**</td>
</tr>
<tr>
<td>Dog</td>
<td>(0.72 to 1.00)</td>
<td>(0.68 to 1.10)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.77</td>
<td>0.71 to 0.93</td>
</tr>
<tr>
<td><strong>Peer problems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any pet</td>
<td>0.70</td>
<td>0.17</td>
</tr>
<tr>
<td>Dog</td>
<td>(1.04 to 1.50)</td>
<td>(0.96 to 1.42)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.91</td>
<td>0.84</td>
</tr>
<tr>
<td>Dog and cat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other pet only</td>
<td>0.89</td>
<td>0.87</td>
</tr>
<tr>
<td>Total SDQ score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any pet</td>
<td>0.87</td>
<td>0.81**</td>
</tr>
<tr>
<td>Dog</td>
<td>(0.72 to 1.00)</td>
<td>(0.68 to 1.10)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.77</td>
<td>0.71 to 0.93</td>
</tr>
</tbody>
</table>

\*p < 0.05, **p < 0.01
Models adjusted for family structure, presence of younger or older siblings, renting home, primary carer's psychological distress, household income, work status, education level and neighbourhood SEIFA. No pets (non-pet owners) was the reference group in all models.
Table 5. Longitudinal associations between pet ownership type and children’s emotional symptoms, peer problems and prosocial behaviour in the kindergarten cohort from ages 4-5 and 6-7 years; Longitudinal Study of Australian Children¹.

<table>
<thead>
<tr>
<th>Pet Ownership</th>
<th>Emotional symptoms $\beta$ (95% CI)²</th>
<th>Peer problems $\beta$ (95% CI)²</th>
<th>Prosocial behaviour $\beta$ (95% CI)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog only (within)</td>
<td>-0.02 (-0.16, 0.12)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dog only (between)</td>
<td>0.05**</td>
<td>-0.14 (-0.24, -)</td>
<td></td>
</tr>
<tr>
<td>Dog only</td>
<td>0.05**</td>
<td>0.22 (0.12, 0.33)**</td>
<td>0.14 (0.00, 0.27)</td>
</tr>
<tr>
<td>Cat only</td>
<td>0.04**</td>
<td>0.17**</td>
<td>0.01 (-0.14, 0.13)</td>
</tr>
<tr>
<td>Dog and cat</td>
<td>-0.04 (-0.17, 0.09)</td>
<td>-0.09 (-0.21, 0.03)</td>
<td>0.14 (0.00, 0.27)</td>
</tr>
<tr>
<td>Other pet only</td>
<td>0.00 (-0.11, 0.12)</td>
<td>-0.09 (-0.20, 0.02)</td>
<td>0.15 (0.03, 0.27)*</td>
</tr>
</tbody>
</table>

¹ Models adjusted for family structure, presence of younger or older siblings, renting home, primary carer’s psychological distress, household income, work status, education level and neighbourhood SEIFA. No pets (non-pet owners) were the reference group in all models.

² The dog only group were sufficiently powered to examine within and between dog owner effects. This was validated using the emotional symptoms scale.
Supplemental table 1: Associations between initial characteristics and the probability of being included in the longitudinal panel analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog only</td>
<td>1.05</td>
<td>(0.81 - 1.37)</td>
</tr>
<tr>
<td>Cat only</td>
<td>1.10</td>
<td>(0.78 - 1.55)</td>
</tr>
<tr>
<td>Dog and cat only</td>
<td>0.94</td>
<td>(0.69 - 1.28)</td>
</tr>
<tr>
<td>Other type of pet only</td>
<td>0.93</td>
<td>(0.67 - 1.30)</td>
</tr>
<tr>
<td>Emotional symptoms abnormal</td>
<td>0.77</td>
<td>(0.54 - 1.09)</td>
</tr>
<tr>
<td>Peer problems abnormal</td>
<td>0.74*</td>
<td>(0.56 - 0.98)</td>
</tr>
<tr>
<td>Prosocial behaviour abnormal</td>
<td>0.77</td>
<td>(0.47 - 1.25)</td>
</tr>
<tr>
<td>Hyperactivity abnormal</td>
<td>1.02</td>
<td>(0.74 - 1.40)</td>
</tr>
<tr>
<td>Male</td>
<td>1.19</td>
<td>(0.98 - 1.46)</td>
</tr>
<tr>
<td>Child's age (years)</td>
<td>1.19</td>
<td>(0.76 - 1.87)</td>
</tr>
<tr>
<td>Has an elder sibling in the home</td>
<td>1.02</td>
<td>(0.82 - 1.27)</td>
</tr>
<tr>
<td>Has a younger sibling in the home</td>
<td>0.95</td>
<td>(0.76 - 1.18)</td>
</tr>
<tr>
<td>One parent family</td>
<td>0.98</td>
<td>(0.73 - 1.30)</td>
</tr>
<tr>
<td>Employed full-time 30+ hrs/week</td>
<td>0.90</td>
<td>(0.67 - 1.22)</td>
</tr>
<tr>
<td>Unemployed or not in the labour force</td>
<td>0.86</td>
<td>(0.68 - 1.09)</td>
</tr>
<tr>
<td>Parent completed a tertiary degree</td>
<td>1.19</td>
<td>(0.92 - 1.55)</td>
</tr>
<tr>
<td>Parent completed Year 10</td>
<td>2.00**</td>
<td>(1.43 - 2.78)</td>
</tr>
<tr>
<td>Household equivalised income (z-standardised)</td>
<td>1.32*</td>
<td>(1.01 - 1.72)</td>
</tr>
<tr>
<td>Renting home</td>
<td>0.49**</td>
<td>(0.39 - 0.62)</td>
</tr>
<tr>
<td>SEIFA Advantage/Disadvantage (z-standardised)</td>
<td>1.08</td>
<td>(0.95 - 1.22)</td>
</tr>
</tbody>
</table>
Primary caregiver level of psychological distress (z-standardised) 1.05 (0.95 - 1.15)
Metropolitan region 0.79* (0.63 - 0.98)

Observations 3,494
Number included in the sample 3017
Pseudo R2 0.0511
P value 0.193

Notes: Results are from logit regressions. The dependent variable takes the value of one if the child is included in the panel regression and zero if the child is not. Sample: Kindergarten cohort children from waves 1 and 2 with no missing information on all included variables. P value is from an F test for joint significance of variables describing pet ownership status and initial mental health conditions. No pets (non-pet owners) was the reference group in all models. ** p<0.01, * p<0.05.
Figure 1 online
Click here to download high resolution image

Figure 1: Data waves combined for cross-sectional and longitudinal analyses.
STROBE Statement—Checklist of items that should be included in reports of cohort studies

<table>
<thead>
<tr>
<th>Item No</th>
<th>Recommendation</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title and abstract</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1       | (a) Indicate the study’s design with a commonly used term in the title or the abstract  
(b) Provide in the abstract an informative and balanced summary of what was done and what was found | 1, 3    |
| **Introduction** | | |
| 2       | Explain the scientific background and rationale for the investigation being reported | 5-6    |
| 3       | State specific objectives, including any prespecified hypotheses | 6 & 7  |
| **Methods** | | |
| 4       | Present key elements of study design early in the paper | 1, 6    |
| 5       | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6    |
| 6       | (a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up  
(b) For matched studies, give matching criteria and number of exposed and unexposed | 6 refs |
| 7       | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 7-8    |
| 8       | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 7-8    |
| 9       | Describe any efforts to address potential sources of bias | 6 refs |
| 10      | Explain how the study size was arrived at | 6 refs |
| 11      | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 7-9    |
| 12      | (a) Describe all statistical methods, including those used to control for confounding  
(b) Describe any methods used to examine subgroups and interactions  
(c) Explain how missing data were addressed  
(d) If applicable, explain how loss to follow-up was addressed  
(e) Describe any sensitivity analyses | 8-9    |
| **Results** | | |
| 13      | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed  
(b) Give reasons for non-participation at each stage  
(c) Consider use of a flow diagram | refs |
| 14      | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders  
(b) Indicate number of participants with missing data for each variable of interest  
(c) Summarise follow-up time (eg, average and total amount) | 9 and T1 |
| 15      | Report numbers of outcome events or summary measures over time | T1, refs |
Main results 16  
(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included  
(b) Report category boundaries when continuous variables were categorized  
(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period  

Other analyses 17  Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses  

Discussion  
Key results 18  Summarise key results with reference to study objectives  
Limitations 19  Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias  
Interpretation 20  Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence  
Generalisability 21  Discuss the generalisability (external validity) of the study results  

Other information  
Funding 22  Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based  

*Give information separately for exposed and unexposed groups.