Epidemiol. Infect. (2006), **134**, 926–934. © 2006 Cambridge University Press
doi:10.1017/S0950268806006078 Printed in the United Kingdom

Does dog or cat ownership lead to increased gastroenteritis in young children in South Australia?

J. S. HEYWORTH[1]*, H. CUTT[1] AND G. GLONEK[2]

[1] *School of Population Health, The University of Western Australia, Crawley, Western Australia*
[2] *School of Mathematical Sciences, The University of Adelaide, Adelaide, South Australia*

(*Accepted 6 January 2006, first published online 29 March 2006*)

SUMMARY

The aim of this study was to investigate the relationship between dog and cat ownership and gastroenteritis in young children. A diary study of 965 children aged 4–6 years living in rural or semi-rural South Australia was undertaken. Data were collected on pet ownership, drinking water and other risk factors for gastroenteritis. Overall 89% of households had pets and dog ownership was more common than cat ownership. The multivariable models for gastroenteritis and pet ownership indicated that living in a household with a dog or cat was associated with a reduced risk of gastroenteritis (adj. OR 0·71, 95% CI 0·55–0·92; OR 0·70, % CI 0·51–0·97 respectively). This paper adds to the evidence that pets are not a major source of gastroenteritis in the home and lends support to the health benefits of pet ownership. However, this must be weighed against the potential negative consequences, such as dog bites, particularly for this age group.

INTRODUCTION

In many industrialized countries the level of pet ownership is high. In Australia and the United States, almost 65% of households own a pet, with up to 40% owning a dog [1, 2]. This high level of ownership indicates the value and importance pets play in modern society [3]. However, companion animals are potentially an important source of gastrointestinal infection [4]. Children are considered to be at particular risk because they spend considerable time in close contact with their pets [4–6] and also at greater risk of gastroenteritis [7].

Humans can become infected with gastrointestinal disease, usually by the oral route, by pathogens shed in the faeces of either carriers or symptomatic animals. This may be by direct ingestion of faeces from contaminated hands or indirectly, through contaminated soil. Humans are considered more likely to acquire infections from cats than dogs, because cats' paws become contaminated when they rake soil or litter over their faeces [4]. As a result, *Salmonella* spp., for example, have consistently been found orally in cats. If a dog or cat have symptoms such as diarrhoea, the risk of transmission may be increased. Dogs affected with *Cryptospordium parvum* have been found to be typically less than 6 months old and to have concurrent diseases such as distemper or parvovirus enteritis [8].

Epidemiological studies do not present a consistent pattern of increased risk associated with pet contact. While some studies have shown an increased risk of gastroenteritis associated with cat or dog contact [9–11], others have shown a protective effect [12, 13]. Furthermore, some studies implicate dogs but not cats and other studies suggest the reverse [14, 15]. Puppies are more consistently implicated than are dogs or cats [13, 16–18].

* Author for correspondence: Dr J. Heyworth, School of Population Health, The University of Western Australia, 35 Stirling Highway, Crawley WA 6009, Australia.
(Email: Jane.Heyworth@uwa.edu.au)

The effect of exposure to pets on specific gastrointestinal diseases has also been considered. In a number of studies [9–11, 18] contact with pets, regardless of type, has been found to be a risk factor for campylobacteriosis. On the other hand, a case-control study in New Zealand did not find pet ownership to be associated with campylobacteriosis, although handling of puppy manure was associated with an increased risk of this disease (OR 9·95, 95% CI 1·17–84·34) [13]. Moreover, an Australian study found that animal contact at home was protective against sporadic cryptosporidiosis [12]. The odds of cryptosporidiosis among people who had animal contact at home compared with no contact were 0·6 (95% CI 0·4–0·9). Furthermore, household dog or cats were not found to be associated with giardiasis in a retrospective study of sporadic giardiasis [19].

Infectious agents have been detected in the faeces of dogs and cats. A study of 255 dogs admitted to an animal hospital in London, United Kingdom (UK), found an overall prevalence of *Giardia* spp. of 15% (37 dogs) with the highest prevalence of 29% in dogs aged 6 months to 1 year [20]. Similarly, surveys of canine populations have reported *Giardia* spp. prevalence rates of 10% in well-cared for dogs, 30–50% in puppies and up to 100% in breeding establishments and kennels [21].

Overall the relationship between gastroenteritis and contact with healthy pets is not clear, yet the potential for zoonotic transmission is plausible. The aim of the present paper is to investigate the role of dog and cat ownership in gastroenteritis among young children, using data collected in a 1999 South Australian cohort study of risk factors for childhood gastroenteritis. In that study the primary focus was on the role of drinking water as a risk factor for gastroenteritis. However, data on a range of risk factors including pet ownership and exposure to sick animals were also collected, in order to investigate the impact of these factors on childhood gastroenteritis.

METHODS

Study population

The sample considered here consisted of 965 rural South Australian children included in a study of gastroenteritis and water consumption [22]. In that study, an initial sample of 3413 children was enrolled (phase 1 of the study) and data on gastroenteritis and potential risk factors in the previous 2 weeks were collected. In the second phase of that study, a subset of the initial sample was followed for a period of 6 weeks and daily data on gastroenteritis were collected using a diary. Children were eligible for the second phase of the study, if (1) they lived in the Adelaide hills (a semi-rural area 15–40 km east of Adelaide) or rural South Australia; (2) they did not have an ongoing illness or treatment that led to gastrointestinal symptoms; (3) their parents indicated that they would be willing to be involved in a further study and (4) children drank public mains water that was filtered and disinfected or drank tank rainwater. The fourth eligibility criterion was required for the investigation of the impact of drinking water on health, as that was one of the objectives of the main study. While in the initial sample (phase 1), pet ownership was greater among households drinking tank rainwater (75%) compared with public mains water (68%), the water source did not confound the relationship between gastroenteritis and pet ownership.

In the initial sample, pet ownership overall was 70%, with 67% of urban households having pets and 75% of rural households.

Children of Aboriginal or Torres Strait Islander descent (ATSI) were excluded because of the difficulty of controlling for the poor environmental health conditions experienced by many of these children in remote communities [23, 24].

Among the 3413 rural respondents to the initial survey, 1960 parents (57%) indicated their willingness to participate in a further study. Of the willing respondents, 869 children were ineligible under the criteria described above and 49 children were no longer contactable, leaving 1042 children available for the current study. All parents of the 1042 children were invited to participate. Entrance into the study occurred over a 3-month period from January to March 1999.

Survey instruments

Participants in phase 2 of the study completed four survey instruments: a baseline questionnaire; a 6-week daily diary; and 3- and 6-week telephone questionnaires. Data on gastrointestinal and respiratory symptoms and also risk factors for gastroenteritis that were likely to vary on a daily basis were collected daily via the 6-week diary. Risk factors included antibiotic use, hay fever and consumption of water and other drinks. The baseline questionnaire and telephone questionnaires at 3 and 6 weeks obtained data on

factors that had greater salience for recall and would not vary greatly over the 6-week diary period. Pet ownership data was collected in the baseline questionnaire and at the 3- and 6-week telephone interviews, parents were asked about their children's contact with sick pets. Other data collected from the surveys included, number of children in household, contact with farm animals, preschool or school attendance rates, swimming location, hygiene behaviours and days spent away from home by the child.

Parents were also provided with an information booklet that included clarification on the meaning of different gastrointestinal symptoms and other assistance for completing the diary. All survey instruments were piloted among parents with young children before the study commenced. The reliability of the survey items was found to be reasonable when responses to the initial survey (phase 1) and the baseline survey for the current study (phase 2) were compared [25]. In each study the 2-week incidence of gastroenteritis was around 14%. Other variables that were available from the two surveys were: main source of drinking water, pets in the home; regular contact with farm animals and consumption of takeaway foods. The kappa statistics (and level of agreement) for each of these items were 0·67 (82·3%), 0·43 (83·3%), 0·70 (87·9%), and 0·43 (66·1%) respectively. While these kappa statistics ranged from moderate to substantial [26], the time between the two surveys and the preliminary questionnaire of the rural cohort study may have been up to 1 year. Hence it was quite possible that some characteristics may have changed over that time period.

Definition of gastroenteritis

The definition of gastroenteritis was based upon highly credible gastrointestinal symptoms (HCGI) used by Payment *et al*. [27] HCGI was defined as the presence of vomiting or liquid bowel movements, or nausea or soft bowel movement/s combined with abdominal cramps in a 24-h period, unless a chronic cause for these symptoms was known to exist. A new episode of gastroenteritis was defined when there were seven symptom-free days preceding the onset of gastrointestinal symptoms.

Statistical analysis

Logistic regression was used to model the dependence of the binary response, HCGI, on pet ownership. Because the response variable was recorded daily for each subject, the data were considered as repeated measures and random-effects models were used to allow for correlation in the data [28]. Descriptive statistics and single variable and multivariable analyses were computed using STATA version 8 software (StataCorp, College Station, TX, USA).

The approach taken to modelling followed the stages recommended by Kleinbaum & Klein [29] (1) variable specification; (2) interaction and confounding assessment and (3) selection of the final model. Variable specification was determined by incorporating those variables that have been shown in the literature to be risk factors for gastroenteritis, including potential confounders. Those for which the association with gastroenteritis was significant at a P value of $<0{\cdot}25$ in a simple regression model, were considered as potential confounders in the full model [30]. Variables that were considered potential confounders on a biological basis were also considered in the full model. Evidence of confounding in the full model was then assessed by comparing the estimated odds ratio of subsets of the full model to that obtained from the full model. A meaningful difference in these odds was a change in the estimated effect on HCGI associated with pets of 5% or greater.

For ease of interpretation, a parsimonious model was derived from the full model by stepwise removal of predictors that were not confounders and not significant at the 5% level.

Ethics approvals

Ethics approval for this study was granted by the South Australian Child and Youth Health Ethics Committee and Social and Behavioural research Ethics Committee of Finders University, South Australia.

RESULTS

Of the 1042 parents who were approached to participate, 1015 (97·4%) agreed. Of these 982 children (94·2%) completed at least one survey instrument and 965 (95·1%) completed the diary. Over the 6-week diary period there were 524 episodes of HCGI among 965 children. Forty-three per cent of children ($n=414$) had one at least one episode. The incidence of HCGI was 5·32 episodes per child-year (95% CI 4·87–5·80) [31].

There was no difference in the proportion of households with pets by willingness to participate;

https://doi.org/10.1017/S0950268806006078 Published online by Cambridge University Press

74% among those willing, and 75% among those not willing to participate had pets in the household. However, the 2-week incidence of gastroenteritis determined from the initial phase one survey was higher among the willing *vs.* non-willing participants; 16 and 13% respectively ($\chi^2 = 11{\cdot}6$, $P < 0{\cdot}01$). The 2-week incidence of gastroenteritis in the baseline survey of the second phase of this study was 14%.

The demographic and household characteristics of the children are shown in Table 1.

Overall 89% of households had pets. Dog ownership (64%) was more common than cat ownership (44%). Other pets included guinea pigs, rabbits, domestic chickens, other birds, pet mice/rats, tortoises, and fish. There was no difference in dog ownership by sex of the participant, but for cats, a significantly higher proportion of girls lived in households with a cat (girls 48%, boys 42%, $P = 0{\cdot}04$). In 26% of households children had regular contact with farm animals. Just 6% of children had had contact with a sick pet during the diary study.

When the proportion of pets by age structure of the household was considered, a significant association ($P < 0{\cdot}01$) was observed. A higher proportion of households with children aged 5–15 years had pets, 93% compared with 84% among households with children aged <5 years. Eighty-seven per cent of households with children aged from 0 to 15 years had pets.

Pet ownership and gastroenteritis

Among the households with a dog, 42% of children were reported to have had HCGI compared with 46% of children in households without a dog ($P = 0{\cdot}23$). For households with cats the respective percentages were 42 and 44% ($P = 0{\cdot}50$). The incidence rates of gastroenteritis in children are less in households with a dog, cat or both, but these are not statistically significantly different from the rate in household without a dog or cat (Table 2). The unadjusted odds ratios, with a reference category of not having a dog or cat, were: 0·71 (95% CI 0·54–0·91) for a dog alone; 0·72 (95% CI 0·52–1·00) for cat alone; and 0·79 (95% CI 0·52–1·02) for both a dog and a cat.

Potential confounders

The variables considered in the full model were: sex; antibiotic use; contact with farm animals; ear infection; sore throat; hay fever symptoms; contact inside

Table 1. *Demographic and household characteristics of participants in the Rural SA Childhood Gastroenteritis Diary Study* ($n = 965$)

	All children*	
Risk factor	*n*	%
Age of child (yr)		
4	141	14·7
5	795	82·6
6	26	2·7
Sex		
Male	521	54·0
Female	444	46·0
Pets in household		
Any pet		
No	102	10·6
Yes	860	89·4
Dog		
No	351	36·5
Yes	611	63·5
Cat		
No	534	55·5
Yes	428	44·5
Other pet/s		
No	369	38·4
Yes	593	61·6
Regular contact with farm animals		
No	710	74·3
Yes	246	25·7
Contact with a sick pet		
No	900	94·2
Yes	55	5·8
Childcare		
No formal childcare	840	87·4
Childcare or family day care or both	68	7·1
After school care	53	5·5
No. of other children aged <5 yr		
0	388	40·5
1	381	39·7
⩾2	190	18·1
No. of other children aged 5–15 yr		
0	67	7·0
1	357	37·5
2	323	33·9
3	132	13·8
⩾4	74	7·8
Socioeconomic status		
Lowest	225	23·5
Lower middle	367	38·4
Upper middle	212	22·1
Highest	153	16·0

* Because of missing values, not all sum to the total *n* of 965.

https://doi.org/10.1017/S0950268806006078 Published online by Cambridge University Press

Table 2. *Incidence rate of HCGI in children by household pet ownership*

	No. of episodes of HCGI	Days at risk	Incidence per child-year (95% confidence interval)
Not dog or cat	133	7763	6·25 (5·28–7·41)
Dog alone	152	11 319	4·90 (4·18–5·75)
Cat alone	64	4779	4·89 (3·83–6·24)
Both dog and cat	156	10 662	5·34 (4·56–6·25)

HCGI, Highly credible gastrointestinal symptoms.

the home with someone who had vomiting or diarrhoea; contact outside the home with someone who had vomiting or diarrhoea; month of diary; attendance at school or kindergarten; number of children aged $\leqslant$15 years; frequency of takeaway consumption; frequency of eating at café and restaurant; storage of leftovers; wheeze in the past year; asthma medication during diary period; and where a child swam. The variables, washing hands after playing with animals and contact with a sick pet, were modelled both as potential confounders and interaction terms.

None of the above variables had an important impact on the magnitude of the relationship between dog or cat ownership and gastroenteritis, but several were important independent risk factors (Table 3).

Parents were asked about their child's hand-washing behaviour in three situations; after playing with animals, before eating meals and after going to the toilet. Not surprisingly, hand-washing behaviour was greatest after going to the toilet (78% mostly or always), whereas hand washing after playing with animals was less regular (41% mostly or always). Overall, approximately half the children washed their hands only sometimes. A greater proportion of girls (45%) compared with boys (38%) washed their hands after playing with animals, but this difference was not statistically significant ($P=0{\cdot}07$).

The interaction terms for washing hands after playing with animals and pet ownership, and contact with sick pets and pet ownership were not statistically significant and were not included in the full model (Table 3).

DISCUSSION

This study found that pet ownership in rural households with at least one child aged 4–6 years was high; 89% compared with 65% for all Australian households. This study also found a reduction in risk of gastroenteritis associated with pet ownership. The adjusted odds of gastroenteritis for rural children aged 4–6 years living in a household with either a dog alone or a cat alone were significantly less than that for children without a dog or cat in the household. The same reduction in risk was seen for children in households with both a dog and a cat, but this did not reach statistical significance.

The incidence of gastroenteritis was higher than reported in previous studies of childhood gastroenteritis [31], but the previous survey of South Australian children [22] estimated the incidence to be of a similar magnitude, 3·69 episodes per child-year. A national survey in Australia reported a lower incidence with a monthly incidence of 20% among children aged 0–5 years (approximately 2·5 episodes per child-year) [32]. In The Netherlands the incidence was 0·90 per child-year for children aged 1–5 years [33] and using the National Health Survey data in the United States an incidence rate of diarrhoea was estimated to be between 1·3 and 2·3 episodes per child aged $\leqslant$5 years per year [34]. The variability in this range in part reflects the differing definitions of gastroenteritis and is a likely explanation for reason for the higher incidence reported here [25, 31]. The definition used in the current study was designed to be broad and capture mild to more severe gastroenteritis. As a result the definition was sensitive at the expense of specificity, and may have exaggerated the incidence [31].

This study had a relatively large sample size of young children and a high response fraction with minimal loss to follow-up. Daily collection of health outcomes minimized recall bias and the final model appeared to have face validity. For example, factors that were expected to be related to gastroenteritis, such as contact with a person ill with gastroenteritis, were found to be associated with a significantly increased risk of gastroenteritis. However, in future studies data on length of pet ownership, type of pet,

Table 3. *Full model HCGI and pet dog or cat ownership – multivariable random effects logistic regression (34 703 days at risk)*

	HCGI		
Variable	OR	95% CI	*P* value
Pet in household			0·04
No dog or cat	1 (ref.)		
Dog alone	0·71	0·55–0·92	
Cat alone	0·70	0·51–0·97	
Both dog and cat	0·81	0·63–1·05	
Sore throat, cold or influenza			<0·01
No	1 (ref.)		
First day of episode	3·35	2·29–4·90	
Subsequent day of episode	2·18	1·73–2·77	
First day of earache or infection			<0·01
No	1 (ref.)		
Yes	2·81	1·30–6·05	
First day of antibiotic use			<0·01
No	1 (ref.)		
Yes	5·01	2·39–10·54	
Contact *inside* the home with a person who had gastroenteritis on the same day			<0·01
No	1 (ref)		
Yes	2·10	1·20–3·66	
Contact with a person who had gastroenteritis *inside* the home same day or in previous 3 days			0·02
No	1 (ref.)		
Yes	1·78	1·09–2·90	
Contact with a person who had gastroenteritis *outside* the home on the same day			<0·01
No	1 (ref.)		
Yes	3·51	2·42–5·07	
Do not know	1·21	1·00–1·47	
Swam during diary period			0·057
No	1 (ref.)		
Yes, in a private pool	1·54	1·04–2·29	
Yes, swam elsewhere	0·98	0·77–1·24	
Wheeze in the last year			<0·01
No	1 (ref.)		
Yes	1·30	1·07–1·58	
Average frequency of consumption of takeaway foods			<0·01
<1 time per week	1 (ref.)		
⩾1 times per week	1·39	1·12–1·72	
Month			0·08
February	1 (ref.)		
March	0·92	0·72–1·17	
April	0·75	0·51–1·10	
May	0·81	0·61–1·07	
June	0·30	0·12–0·75	

HCGI, Highly credible gastrointestinal symptoms.

https://doi.org/10.1017/S0950268806006078 Published online by Cambridge University Press

number and age of pets, and also age of child at time of pet acquisition are needed to clarify the relationship between pet ownership and health outcomes.

While this study was a population-based prospective study on gastroenteritis, the generalizability of the results may be limited as there were higher levels of pet ownership parents, low level of child care use and larger average family size (mean 4·4 person compared with 3·1 for Australia) [35].

Parents may have chosen not to have a cat or dog in their household because their child was prone to illness or allergy. There was an association between dog or cat ownership and doctor-diagnosed asthma, but asthma was not associated with gastroenteritis. For children with asthma, 37% of households had a cat compared with 46% for children without asthma ($P=0{\cdot}03$). For dogs, the respective percentages were 58 and 65% ($P=0{\cdot}07$). This suggests that health of the child may have influenced the decision to own pets. However, when the analyses was limited to only children with asthma the protective effect of dogs, but not cats, was still observed.

The sample in this study was a self-selected sample and in the initial survey, parents who were willing to participate were more likely to have a child who had had gastroenteritis in the previous 2 weeks. Yet, the proportion of children who had gastroenteritis in the initial sample (phase 1) was very similar to that observed in the baseline survey of phase 2 of the current study; both were around 14%. If selection bias had played a significant role, a higher proportion than that previously observed would have been expected. While there were higher levels of dog and cat ownership than commonly reported for the general population, other studies of children and pets have reported high levels of ownership [36]. This finding is also consistent with the findings of the earlier survey of 4-year-old children, which found that 75% of rural households had pets. Rural households also may have a greater proportion of pets as they have dogs which are working as well as companion animals.

Families with children are more likely to own pets [6, 36]. The number of children in the home and the age of children have been shown to be positively related to pet ownership. Families with very young children or infants are less likely to have pets while families with middle-age (8–12 years) and teenage children (13–16 years) are most likely to own pets [6, 36].

A commonly held view is that dogs and cats are a source of gastroenteritis in young children, but the findings of this study suggest otherwise for young rural children. While this study considered the broad spectrum of gastrointestinal illness, from mild (lasting 1 or 2 days) to severe (lasting up to 14 days), the findings are consistent with other studies of specific gastrointestinal illnesses that have been conducted in the region. For example, protective effects of pets on cryptosporidiosis [12] and campylobacteriosis [13] have been reported in Australia and New Zealand respectively.

A possible explanation for the reduced risk of gastroenteritis associated with dog or cat ownership is acquired immunity through low-level chronic exposure to potential microbial contaminants. Payment & Hunter [37] and Robertson *et al.* [12] have raised the hypothesis that previous exposure to microorganisms leads to a degree of pre-existing immunity to gastrointestinal infections in the community. However, the role of acquired immunity is still not well understood and may vary by organism [38, 39].

While the research findings to date are mixed in terms of whether pet ownership is detrimental, neutral or beneficial to health [40, 41], this study lends support to the health benefits of pet ownership. The other potential health benefits for children include social, emotional and physical health benefits, such as improved child development [5, 42–44]. However, the possibility of negative health consequences from dog ownership, particularly for this age group, cannot be ignored. Injury from dog bites is most common in the 0–4 years age group with injuries most commonly to the head and face areas [45, 46].

In conclusion, this study has shown that having a dog or cat is associated with a reduced risk of gastroenteritis. However, further research that incorporates number and age of pets and length of pet of ownership is needed to confirm these findings.

ACKNOWLEDGEMENTS

The support of the South Australian Department of Health in providing funding and other resources for this project is gratefully acknowledged. The research assistance provided by Ingerid Meagher in the data collection for this study is also gratefully acknowledged.

DECLARATION OF INTEREST

None.

REFERENCES

1. **PIAS.** Australian Pet Ownership Statistics, 2002. Petcare Information and Advisory Service (PIAS) (http://www.petnet.com.au). Accessed 21 December 2005.
2. **BIS Shrapnel Pty Ltd.** *Contribution of the Pet Care Industry to the Australian Economy*. Australian Animal Council Inc.: North Sydney, Australia, 2003.
3. **Beck AM, Meyers NM.** Health enhancement and companion animal ownership. *Annual Review of Public Health* 1996; **17**: 247–257.
4. **Carter M, Quinn P.** Salmonella infections in dogs and cats. In Wray C, Wray A, eds. *Salmonella in Domestic Animals*. CABI Publishing: Wallingford, 2000: pp. 231–244.
5. **Melson GF, Schwarz RL, Beck AM.** Importance of companion animals in children's lives – implications for veterinary practice. *Journal of the American Veterinary Medical Association* 1997; **211**: 1512–1518.
6. **Paul ES, Serpell J.** Why children keep pets: the influence of child and family characteristics. *Anthrozoos* 1992; **5**: 231–244.
7. **Gerba C, Rose J, Haas C.** Sensitive populations: who is at the greatest risk? *International Journal of Food Microbiology* 1996; **30**: 113–123.
8. **Denholm K, *et al.*** Concurrent *Cryptosporidium* and parvovirus infections in a dog. *Australian Veterinary Journal* 2001; **79**: 98–101.
9. **Caprioli A, *et al.*** Enteropathogens associated with childhood diarrhoea in Italy. *Pediatric Infectiois Disease Journal* 1996; **15**: 876–883.
10. **Adak GK, *et al.*** The Public Health Laboratory Service national case-control study of primary indigenous sporadic cases of *Camplyobacter* infection. *Epidemiology and Infection* 1995; **115**: 15–22.
11. **Uhnoo I, *et al.*** Aetiology and epidemiology of acute gastro-enterits in Swedish children. *Journal of Infection* 1986; **13**: 73–89.
12. **Robertson B, *et al.*** Case-control studies of sporadic cryptosporidiosis in Melbourne and Adelaide, Australia. *Epidemiology and Infection* 2002; **128**: 419–431.
13. **Eberhart-Phillips J, *et al.*** Campylobacteriosis in New Zealand: results of a case-control study. *Journal of Epidemiology and Community Health* 1997; **51**: 686–691.
14. **Deming M, *et al.*** *Campylobacter* enteritis at a University: transmission from eating chicken and from cats. *American Journal of Epidemiology* 1987; **126**: 526–534.
15. **Kapperud G, *et al.*** Risk factors for sporadic *Campylobacter* infections: results of a case-control study in Southeastern Norway. *Journal of Clinical Microbiology* 1992; **30**: 3117–3121.
16. **Salfield N, Pugh E.** *Campylobacter* enteritis in young children living in households with puppies. *British Medical Journal* 1987; **294**: 21–22.
17. **Neal KR, Slack RC.** Diabetes mellitus, anti-secretory drugs and other risk factors for *campylobacter* gastro-enteritis in adults: a case-control study. *Epidemiology and Infection* 1997; **119**: 307–311.
18. **Tenkate TD, Stafford RJ.** Risk factors for *Campylobacter* infection in infants and young children: a matched case-control study. *Epidemiology and Infection* 2001; **127**: 399–404.
19. **Chute C, Smith R, Baron J.** Risk factors for endemic giardiasis. *American Journal of Public Health* 1987; **77**: 585–587.
20. **Sykes TJ, Fox MT.** Patterns of infection with *Giardia* in dogs in London. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1989; **83**: 239–240.
21. **Barr SC, Bowman DD.** Giardiasis in dogs and cats. *The Compendium on Continuing Education for the Practising Veterinarian* 1994; **16**: 603–611.
22. **Heyworth JS, Baghurst P, McCaul KA.** Prevalence of gastroenteritis among 4-year-old children in South Australia. *Epidemiology and Infection* 2003; **130**: 443–451.
23. **Gracey M.** Diarrhoea in Australian Aborigines. *Australian Journal of Public Health* 1992; **16**: 216–225.
24. **Gunzburg S, *et al.*** Epidemiology and microbiology of diarrhoea in young Aboriginal children in the Kimberley region of Western Australia. *Epidemiology and Infection* 1992; **108**: 67–76.
25. **Heyworth J.** An epidemiological study of childhood gastroenteritis and consumption of rainwater, an untreated water supply in South Australia. In: *School of Medicine*. Flinders University: Adelaide, 2004.
26. **Sim J, Wright C.** *Research in Health Care*. Cheltenham: Stanley Thomas (Publishers) Ltd, 2000.
27. **Payment P, *et al.*** A randomised trial to evaluate the risk of gasrto-intestinal disease due to consumption of drinking water meeting current microbiological standards. *American Journal of Public Health* 1991; **81**: 703–708.
28. **Diggle P, Liang K, Zeger S.** *Analysis of Longitudinal Data*. Oxford: Oxford Science Publications, 1996.
29. **Kleinbaum D, Klein M.** *Logistic Regression, a Self-learning Text*, 2nd edn. New York: Springer-Verlag, 2002.
30. **Hosmer D, Lemeshow S.** *Applied Logistic Regression*. New York: John Wiley & Sons, 1989.
31. **Heyworth J, *et al.*** Incidence, Impact on the family and cost of gastroenteritis among 4- to 6-year-old children in South Australia. *Journal of Gastroenterology and Hepatitis* 2006 (in press).
32. **Ashbolt R, *et al.*** Enhancing foodborne surveillance across Australia in 2001: the OzFoodNet Working Group. *Communicable Diseases Intelligence* 2002; **26**: 375–406.
33. **de Wit MA, *et al.*** Sensor, a population-based cohort study on gastroenteritis in the Netherlands: incidence and etiology. *American Journal of Epidemiology* 2001; **154**: 666–674.
34. **Glass R, *et al.*** Estimates of morbidity and mortality rates for diarrheal diseases in American children. *Journal of Pediatrics* 1991; **118**: S27–S33.
35. **Australian Bureau of Statistics.** Family Characteristics Australia, cat. no. 4442.0. ABS, 2004: Canberra.

36. **Albert A, Bulcroft K.** Pets, families, and the life course. *Marriage and Family Review* 1988; **50**: 543–552.
37. **Payment P, Hunter P.** Endemic and epidemic infectious intestinal disease and its relationship to drinking water (chapter 4). In: Fewtrell L, Batram J, eds. *Water Quality-Guidelines, Standards and Health: Assessment of Risk and Risk Management for Water-Related Infectious Disease*. IWA on behalf of WHO: London, 2001: pp. 61–88.
38. **Glass R, *et al.*** Gastroenteritis viruses: an overview. Novartis Foundation Symposium, 2001.
39. **Frost FJ, *et al.*** A two-year follow-up survey of antibody to Cryptosporidium in Jackson County, Oregon following an outbreak of waterborne disease. *Epidemiology and Infection* 1998; **121**: 213–217.
40. **Garrity TF, Stallones L.** Effects of pet contact on human well-being. In: Wilson CC, Turner DC, eds. *Companion Animals in Human Health*. Sage Publications: Thousand Oaks, 1998: pp. 3–22.
41. **Pachana NA, *et al.*** Relations between companion animals and self-reported health in older women: cause, effect or artifact? *International Journal of Behavioral Medicine* 2005; **12**: 103–110.
42. **McNicholas J, Collis G.** Children's representations of pets in their social networks. *Child: Care, Health and Development* 2001; **27**: 279–294.
43. **Salomon A.** Animals and children: the role of the pet. *Canada's Mental Health* 1981; **29**: 9–13.
44. **Wood L, Giles-Corti B, Bulsara M.** The pet connection: pets as a conduit for social capital? *Social Science and Medicine* 2005; **61**: 1159–1173.
45. **Thompson PG.** The public health impact of dog attacks in a major Australian city. *Medical Journal of Australia* 1997; **167**: 129–132.
46. **Bernardo LM, Gardner MJ, Amon N.** Dog bites in children admitted to Pennsylvania trauma centers. *International Journal of Trauma Nursing* 1998; **4**: 121–127.