Does dog ownership really prolong survival? A revised meta-analysis and reappraisal of the evidence

Bauman, A., Owen, K. B., Torske, M. O., Ding, D., Krokstad, S. & Stamatakis, E.

Published in: Circulation: Cardiovascular Quality and Outcomes
DOI: 10.1161/CIRCOUTCOMES.120.006907

Available online: 20 Oct 2020

Citation:
Bauman, A., Owen, K. B., Torske, M. O., Ding, D., Krokstad, S. & Stamatakis, E. (2020). Does dog ownership really prolong survival? A revised meta-analysis and reappraisal of the evidence. Circulation: Cardiovascular Quality and Outcomes, 13(10): e006907. doi: 10.1161/CIRCOUTCOMES.120.006907

Title page

COMMENTARY: Does Dog ownership really prolong survival? a revised meta-analysis and re-appraisal of the evidence

Adrian Bauman* PhD 1,2 Katherine B Owen PhD 2 , Magnhild Oust Torske PhD 3, Ding Ding PhD 1 , Steinar Krokstad MD 2 , Emmanuel Stamatakis PhD 1, 4

1 School of Public Health and Charles Perkins Centre, Building D17, Sydney University, Australia 2006

2 HUNT Research Center, Norwegian University of Science and Technology, Trondheim, Norway

3 Faculty of Biosciences and Aquaculture, Nord University, Steinkjer, Norway

4 School of Health Sciences, Faculty of Medicine and Health, Building D17, Sydney University, Australia 2006

*Corresponding author: Adrian Bauman, Level 6, Charles Perkins Centre D17, Sydney University NSW Australia 2006 Email: adrian.bauman@sydney.edu.au Phone +61 286271851 Orcid: 0000-0002-0369-4621

Many households own a dog, and dog owners are more likely to walk and to meet physical activity guidelines, compared to non-dog owners [1,2]. Other benefits, usually reported in cross-sectional studies, include improved mental wellbeing and reduced cardiovascular risk factors[3]. The evidence on dog ownership to date was summarized by the American Heart Association (2013) as "*probably having some causal role…. in reducing cardiovascular risk*".[4]

In October 2019, Kramer and colleagues published a meta-analysis examining dog ownership and survival using 9 prospective epidemiological studies[5]. This meta-analysis reported a 24% decreased risk of all-cause mortality amongst dog owners compared to non-dog owners. The protective effect was even stronger for the three studies that specifically looked at the risk of cardiovascular events amongst dog owners [5]. The paper was supported by an Editorial that outlined potential prevention mechanisms of dog ownership mediated through increased physical activity, and effects on stress and blood pressure reduction [3].

The authors calculated the ratio of deaths to the population at risk in those exposed and unexposed to dog ownership. The study reported they could only conduct an analysis of pooled *unadjusted* rate ratios [5] (second last paragraph, p7). The Cochrane Collaboration recommends that unadjusted and adjusted estimates both be reported in meta-analyses, as the latter adjusts for important known confounders, and may produce different (risk) estimates, compared to unadjusted meta analyses [6,7]. We initially focused attention on the six population studies with estimates of all-cause mortality risk in the Kramer paper [5]. We calculated adjusted hazard ratios from these papers and re-did this meta-analysis to see if the evidence on dog ownership and mortality remained consistent. We extracted estimates from the papers that adjusted for the maximum number of covariates available, as recommended by the Cochran Collaboration [6] (see Supplementary Table S1). We chose the identical random effects meta-analysis methods [5] namely the DerSimonian-Laird Method and the Cochran Q test and I^2 values to assess heterogeneity between studies, and used the 'Metagen' package in 'R' (R Foundation for Statistical Computing, Vienna, Austria). Where possible, the hazard ratios (HR) were extracted rather than the risk ratio, as the HR accounts for not only the occurrence of an event, but also the timing of the event.

We present our adjusted meta-analysis for all-cause mortality (Table 1 italics and Figure 1a) and reproduce the original analysis (Figure 1b) [5]. Compared to the original analysis (unadjusted relative risk 0.76 (95%CI 0.67-0.86) we found a different picture using adjusted estimates (Figure 1a, four of the five adjusted hazard ratios[8-12] showing a nonsignificant effect, and the only significant effect coming from Mubanga[13]). Our adjusted pooled estimate from the six population-based studies was nonsignificant, ES[14] (Effect size) of 0.95 (0.85-1.05). In our re-analysis, the three studies by Friedmann[15-17] in people with existing cardiovascular disease show that dog ownership remains significantly associated with survival (RR 0.39, 95%CI 0.20-0.77), but we note that no adjusted estimates were available. In contrast to the original meta-analysis which used the unadjusted relative risk (RR=0.49), we used the hazard ratio (HR=0.60). Overall, the adjusted RR for the association between dog ownership and survival based on all of these 9 papers combined was not significant (Figure 1a, RR=0.93 (0.83-1.03).

Further issues relate to the choice of fixed or random effects meta-analysis [7]. Random effects models assume underlying true effect sizes vary across cohorts, due to participants from different populations with different levels potential confounders, such as physical activity levels or health status. For random effect models, studies of different sample sizes tend to have more similar weights. While in fixed effect models, studies were weighted in proportion to their sample sizes (see supplementary Table S1 for cohort sample sizes). In order to address this, we conducted six additional meta analyses on these data (Table 1). Pooled estimates in the fixed effects models were statistically significant but substantially influenced by the one very large Swedish study (which contributed 92% of all participants across all population studies used here[13]) although the adjusted estimated attenuated the effect towards the null. Excluding this study showed further attenuation, which was still marginally significant only in the fixed effects model (RR=0.96). In order to demonstrate the effect of the large single Swedish study,[13] we hypothetically modelled if the results would change if in future, there were an additional 8 smaller new epidemiological studies, and the effects would persist as significant only in the fixed effects model (RR=0.88).

In summary, our initial conclusion was different to the significant 24% risk reduction reported in the original meta-analysis [5]. Our adjusted meta-analysis found a statistically nonsignificant 7% risk reduction in the association between dog ownership and all-cause mortality. There is still a protective association among those with pre-existing CVD, but this is limited to three small serial studies by the same author with unadjusted estimates[15-17]. Overall, for all nine studies combined, the adjusted association remains non-significant. One major debate is around the choice of models and, given the undue weighting to the single Swedish study in fixed effects models, these associations remained protective; removing the Swedish study, or using random effects models attenuated or removed this association.

A more recent examination of pet ownership and CVD outcomes[18] showed a non-significant RR_{adj} of 0.99 (0.91-1.08), and for all CVD, RR_{adj} was 0.95 (0.84-1.07), Subgroup analyses did tend to suggest lowered CVD risk estimates among pet owners, but risks for myocardial infarction and stroke did not differ by pet ownership[18]. For the three small, and possibly selected studies on people with cardiovascular disease[15-17] the association remains significant although attenuated slightly by our revised HR estimate. The recent analysis[18], in combination with the original study findings[5] suggest there still may be some cardiovascular benefit associated with dog ownership, but the data do not support an overall benefit.

The original conclusion of the Kramer paper provided positive evidence for dog ownership and achieved the second highest Altmetric research impact score ever for this journal (>2071; Altmetric.com, April 2020). However, including unadjusted estimates may over-estimate risk reduction benefits. It is important to adjust for confounders, as shown in the effects of dog ownership on health, as adjusted estimates attenuate or remove significant associations in these studies, resulting in a slightly more nuanced conclusion. Other methodological considerations are the limitations of pooling hazard ratios and relative risks together [19] and the issue that the covariates adjusted for were not identical across studies. These are methodological concerns for many meta-analyses and do not substantively affect the findings of this revised meta-analysis.

It is likely that our nonsignificant finding may be closer to the "true" pooled estimate. However, we cannot be certain that our findings reflect a true absence of effects of dog ownership on health or whether they are due to methodological limitations in these studies (e.g. lack information about dog characteristics such as breed, age, caretaking/interactions with owners; influences of very large single studies; single measurement of dog ownership (exposure) with no consideration of ownership timeline, and serial dog walking behaviour measures [13]). Further debate around the models used suggest that random effects are generally used, as they reduce the effects of undue weighting given to individual studies in fixed effects models [7]. Although positive effects of dog ownership are a 'hoped-for' conclusion, especially among dog owners, the original results should be treated with caution. Considering that large randomised controlled trials on dog ownership and long-term health outcomes/survival are difficult to conduct[20], further well-designed prospective cohort studies collecting comprehensive information are needed to better characterise the epidemiological evidence that dogs influence longevity, overall and cardiovascular health and wellbeing.

References

1. Christian, HE., Westgarth C., Bauman A., Richards EA., Rhodes, RE., Evenson, KR., Mayer, JA., Thorpe, R J, Jr. Dog ownership and physical activity: a review of the evidence. *J Phys Act Health*, 2013:10(5), 750-759.
2. Westgarth, C., Christley, RM., Jewell, C., German, AJ., Boddy, LM., Christian, HE. Dog owners are more likely to meet physical activity guidelines than people without a dog: An investigation of the association between dog ownership and physical activity levels in a UK community. *Scientific reports*, 2019:9(1), 5704.
3. Kazi, DS. Who Is Rescuing Whom? Dog Ownership and Cardiovascular Health. *Circ Cardiovasc Qual Outcomes*.. 2019;12:e005887.
4. Levine, GN., Allen, K., Braun, LT., Christian, HE., Friedmann, E., Taubert, KA., Thomas SA, Wells D, Lange, RA. Pet ownership and cardiovascular risk: A scientific statement from the American Heart Association. *Circulation*, 2013:127(23), 2353-2363.
5. Kramer, CK., Mehmood, S., Suen, RS.. Dog Ownership and Survival: A Systematic Review and Meta-Analysis. *Circ Cardiovasc Qual Outcomes*, 2019:12(10), e005554. doi: 10.1161/CIRCOUTCOMES.119.005554
6. Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration, updated 2011. www.handbook.cochrane.org. Combining studies: https://handbook-5-1.cochrane.org/chapter_13/13_6_2_2_combining_studies.htm
7. Owen KB, Torske M, Bauman A. Dog Ownership and Survival: Methodological issues in meta-analysis Letter to the Editor. 2020; *Circ Cardiovasc Qual Outcomes* [this issue].
8. Gillum RF, Obisesan TO. Living with companion animals, physical activity and mortality in a U.S. national cohort. *Int J Environ Res Public Health*. 2010;7:2452–2459. doi: 10.3390/ijerph7062452
9. Chowdhury EK, Nelson MR, Jennings GL, Wing LM, Reid CM; ANBP2 Management Committee. Pet ownership and survival in the elderly hypertensive population. *J Hypertens*. 2017;35:769–775. doi: 10.1097/HJH.0000000000001214
10. Torske MO, Krokstad S, Stamatakis E, Bauman A. Dog ownership and all cause mortality in a population cohort in Norway: the HUNT Study. *PLoS One*. 2017;12:e0179832. doi: 10.1371/journal.pone.0179832

11. Ding, D., Bauman, A. E., Sherrington, C., McGreevy, P. D., Edwards, K. M., & Stamatakis, E. Dog Ownership and Mortality in England: A Pooled Analysis of Six Population-based Cohorts. *American Journal of Preventive Medicine*, 2018:54(2), 289-293.
12. Sørensen IK, Bidstrup PE, Rod NH, Rühling T, Johansen C. Is dog ownership associated with mortality? A nationwide registry study. *Eur J Public Health*. 2018;28:1169–1171
13. Mubanga, M., Byberg, L., Nowak, C., Egenvall, A., Magnusson, PK., Ingelsson, E., Fall, T. Dog ownership and the risk of cardiovascular disease and death–a nationwide cohort study. *Scientific reports*, 2017:7(1), 15821
14. Farvid MS, Ding M, Pan A, Sun Q, Chiuve SE, Steffen LM, Willett WC, Hu FB. Dietary linoleic acid and risk of coronary heart disease: a systematic review and meta-analysis of prospective cohort studies. *Circulation*. 2014;130(18):1568-78.
15. Friedmann, E., Katcher, AH., Lynch, JJ., Thomas, SA. Animal companions and one-year survival of patients after discharge from a coronary care unit. *Public Health Reports*, 1980:95(4), 307-312.
16. Friedmann, E., Thomas, SA. Pet ownership, social support, and one-year survival after acute myocardial infarction in the Cardiac Arrhythmia Suppression Trial (CAST). *American Journal of Cardiology*, 1995:76(17), 1213-1217.
17. Friedmann E, Thomas SA, Son H. Pets, depression and long term survival in community living patients following myocardial infarction. *Anthrozoos*.2011;24:273–285.
18. Yeh, TL., Lei, WT., Liu, SJ., & Chien, KL.. A modest protective association between pet ownership and cardiovascular diseases: A systematic review and meta-analysis. *Plos One*, 2019;14(5), e0216231. doi:10.1371/journal.pone.0216231
19. Sutradhar R, Austin PC. Relative rates not relative risks: addressing a widespread misinterpretation of hazard ratios. *Annals of epidemiology*. 2018 1;28(1):54-7
20. Powell L, Edwards KM, McGreevy P, Bauman A, Podberscek A, Neilly B, Sherrington C, Stamatakis E. Companion dog acquisition and mental well-being: a community-based three-arm controlled study. *BMC public health* 2019; 19(1): 1428

Contributions to the paper: all authors contributed to the conceptualisation, design and interpretation of the paper; AB wrote the draft, all commented and redrafted parts of the manuscript. KO performed the revised meta-analyses

Conflicts of interest: AB, ES, MOT, KO and SK declare that they have emotionally vested interests in the topic, as between them they are the devoted owners of five dogs, and MOT is a Veterinarian.

Table 1. Additional meta-analyses: effects of different methods and sensitivity analyses

Model type	Adjustment	Studies included	Mubanga weight	Pooled effect
Random effects Figure 1b	*Unadjusted (Kramer)*	*All*	*17%*	*0.76 (0.67, 0.86)*
Random effects Figure 1a	*Adjusted*	*All*	*19%*	*0.93 (0.83, 1.03)*
Fixed effects	Unadjusted	All	82%	0.72 (0.71, 0.73)
Fixed effects	Adjusted	All	63%	0.86 (0.84, 0.87)
Fixed effects	Adjusted	All except Mubanga (2017)	0%	0.96 (0.93, 0.98)
Random effects	Adjusted	All except Mubanga (2017	0%	0.97 (0.90, 1.04)
Fixed effects	Adjusted	All and an additional new 8 hypothetical smaller studies	46%	0.88 (0.87, 0.89)
Random effects	Adjusted	All and an additional new 8 hypothetical smaller studies	11%	0.94 (0.88, 1.01)

Note the Mubanga 2017 study[13] had a sample size of 3,432,153 (+34,202 Twins)

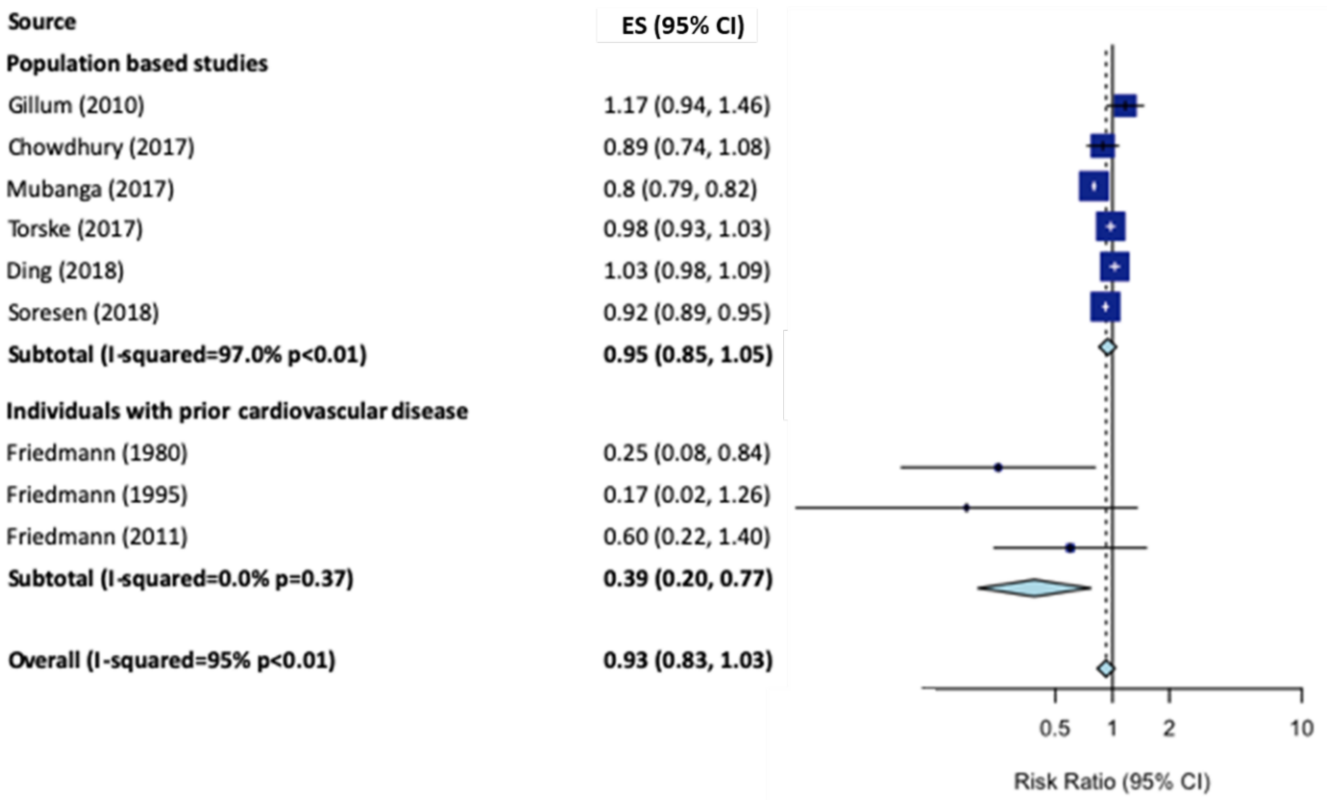

Figure 1a Updated meta-analysis of the adjusted associations between dog ownership and the risk of all-cause mortality [showing adjusted ES: effect size [14]]

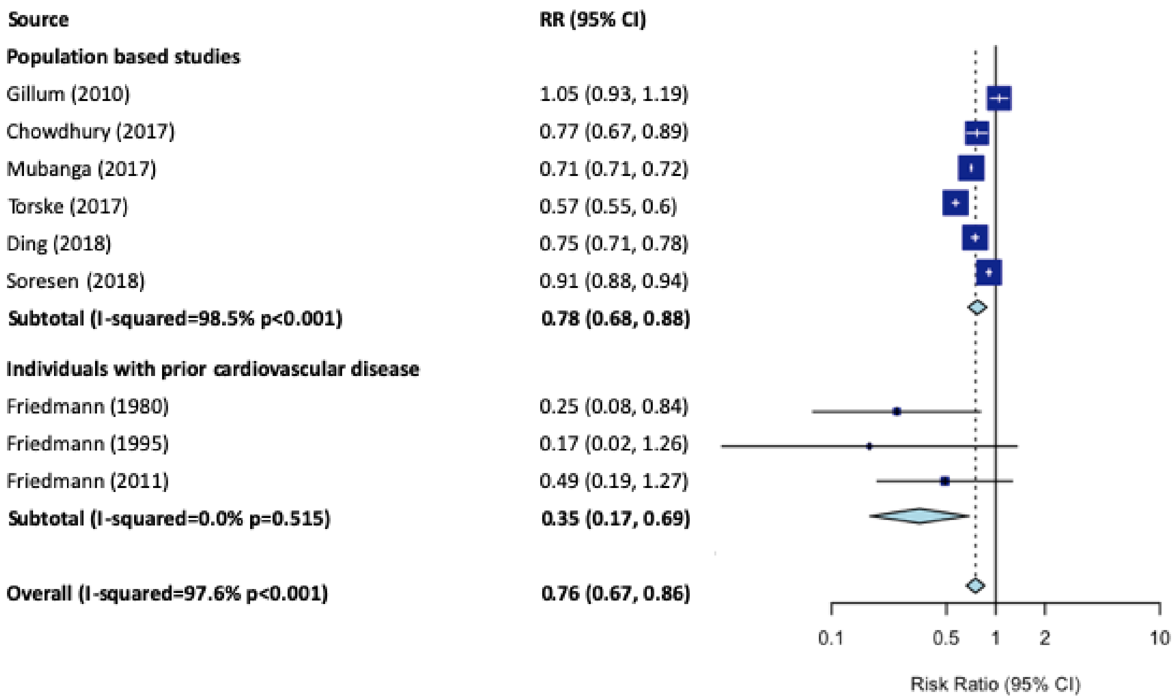

Figure 1b Original meta-analysis[5] of the association between dog ownership and the risk of all-cause mortality *(Figure re-drawn under CC BY-NC 4.0 license from Kramer et al. Circulation CVQO 2019;12;p5).*

(Supplementary) Table S1

Covariates adjusted for in estimates extracted from each study

Source, sample size	Adjusts for
Population based studies[8-13]	
Gillum (2010) N=11394	Age, sex, race, SES, health status, activity level, healthy behaviours and other risk factors
Chowdhury (2017) N=4039	Age, sex, marital status, education, blood pressure, cholesterol, serum HDL, history of diabetes, smoking, BMI, eGFR, physical activity, treatment group and on-treatment blood pressure
Mubanga (2017) N=3,432,153 (+34,202 Twins)	sex, marital status, number of children at home, population density, area of residence, region of birth, income, latitude
Torske (2017) N=25031	age, sex
Ding (2018) N=59352	age, sex, marital status, social class, employment, education, living circumstances, alcohol, smoking, illness
Soresen (2018) N=275184	age, sex, education, income and marital status (through matching)
Individuals with prior cardiovascular disease[15-17]	
Friedmann (1980) N=96	none.
Friedmann (1995) N=424	none.
Friedmann (2011) N=460	none. We included the unadjusted hazard ratio from this paper; this differs from the calculated relative risk included in Kramer 2019.

-