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Longitudinal associations between allostatic load, pet ownership, and socioeconomic position among U.S. adults aged 50+

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ABSTRACT

It is hypothesized that pets provide benefits to human health by buffering the deleterious effects of stress, but varying exposure to chronic stress via social position is rarely considered in these conceptual and empirical models. Allostatic load is an index of biological and physical measures that represents cumulative wear and tear on the body via chronic stress exposure. In this study, we use the 2006–2016 waves of the Health and Retirement Study, a nationally representative, longitudinal panel survey of adults aged 50+ in the United States, to test whether and to what extent pet ownership has an impact on allostatic load, and whether pet ownership moderates the effects of socioeconomic position on allostatic load. Linear mixed effects regression models revealed that pet owners had significantly lower allostatic load scores than those who do not own pets; however, after adjusting for socioeconomic position (i.e., wealth, education, race, ethnicity, gender, marital status), the effect of pet ownership was no longer significant. We estimated a series of models stratified by sociodemographic groups to test moderation effects. Among those who had a high school education, pet owners had lower allostatic load scores, whereas among those who had attended some college, pet owners had higher scores. Among those who were aged 80+, pet owners had higher scores than those who did not own pets. These findings suggest that the magnitude of the effect of pet ownership on allostatic load may not be sufficient to counteract experiences of high chronic stress as experienced by lower-status groups. Supporting the human-animal bond may contribute to improving older adult population health if paired with efforts to address the underlying causes of population health disparities.

1. Introduction

The proportion of older adults in the U.S. population is growing and their increasing life expectancy raises the challenge of identifying factors that facilitate long-term good health and decrease vulnerability to poor outcomes. To this end, cross-sectional and prospective studies have increasingly focused on how social relationships influence health through stress-related physiological systems. For example, more and/or higher quality social relationships are associated with better immune (Kiecolt-Glaser, Gouin, & Hantsoo, 2010), cardiovascular (Baker et al., 2000; Smith & Ruiz, 2002), and metabolic parameters (Helgeson, Lopez, & Kamarck, 2009; Troxel, Matthews, Gallo, & Kuller, 2005). An understudied social relationship that may facilitate health and well-being among older adults via direct and indirect effects on the stress response system stress-reduction is household companion animals (e.g., cats, dogs). The current study addresses gaps in our understanding of the association between pet ownership and allostatic load (AL; a construct that represents physiological dysregulation via chronic stress exposure) in a nationally representative sample of older adults. Specifically, we compare repeated measures of AL between pet owners and non-owners aged 50+ to test whether pet ownership is associated with lower AL scores over time and whether the pet ownership modifies the relationship between socioeconomic position (SEP; i.e., race, ethnicity, wealth, gender, and marital status) and AL.

1.1. Pets and human health

Nearly half of older adults in the U.S. share their lives and homes with at least one companion animal and a majority consider pets to be members of the family (Applebaum, Peek, & Zsembik, 2020; Mueller, King, Callina, Dowling-Guyer, & McCobb, 2021). It is hypothesized that oxytocin and vasopressin act as neurotransmitters and neuromodulators

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that underlie bonds between humans and their pets and that interactions with companion animals (i.e., mammals) can lead to alterations in the autonomic nervous and neuroendocrine systems (Applebaum, MacLean, & McDonald, 2021; McDonald, Tomlinson, et al., 2021). Furthermore, it is hypothesized that positive interactions with pets via behaviors such as touch (petting), gazing at, and affiliative contact, positively impact humans' physiological and emotional state well-being. Indeed, studies of adult samples link petting animals with lower cortisol, heart rate, and/or blood pressure (Barker, Knisely, McCain, & Best, 2005; Handlin et al., 2011; Jenkins, 1986; Odendaal, 2000; Vormbrock & Grossberg, 1988) and increased immunoglobulin A, phenylethylamine, oxytocin, and dopamine (Charnetski, Riggers, & Brennan, 2004; Handlin et al., 2011; Odendaal, 2000). In addition to these physiological consequences of human-animal interaction, pet ownership may have a positive impact on a variety of social and individual factors that play an important role in resilience to stress. For example, pets may offer a positive and nurturing relationship in the context of social isolation or social loss, promote healthy cognitive functioning (i.e., executive functioning), self-regulation, positive self-perception, self-efficacy, and sense of meaning in life (Applebaum, Shieu, McDonald, Dunietz, & Braley, 2022; Bibbo, Curl, & Johnson, 2019; Gee & Mueller, 2019; McDonald et al., 2022; McDonald, Matijczak, et al., 2021; McDonald, Murphy, et al., 2021; Zhang et al., 2022).

A recent systematic review of research on pet ownership and interaction among older adults concluded that "there is real potential for companion animals to beneficially impact the health and wellbeing of older adults, but the evidence base is not strong" (Gee & Mueller, 2019, p. 199). In addition to the lack of population-based research in this area, another limitation is the lack of empirical attention that has been given to examining associations between pet ownership and AL. AL refers to, "the wear and tear on the body and brain resulting from chronic overactivity or inactivity of physiological systems that are normally involved in adaptation to environmental challenge" (McEwen, 1998, p. 37). Thus, AL can be thought of as biological evidence of maladaptive physiological responses to chronic stress (Doan, 2021; McEwen, 1998). Given the underlying hypotheses regarding how pet ownership and interactions impact human health, it is reasonable to hypothesize that older adults who own pets may experience lower AL. To date, we are aware of only one study that has examined associations between pet ownership and AL. Using data from a convenience sample of 106 older adults in Mexico (without controlling for sociodemographic factors) Morales-Jinez et al. (2018) found that dog ownership was predictive of lower AL scores, compared to those who did not own dogs (Morales-Jinez et al., 2018). The researchers concluded that pet dogs may be effective for stress management and reduction in older adults (Morales-Jinez et al., 2018). The current study builds on these findings by examining longitudinal associations between pet ownership, AL, and SEP with known associations to AL in a representative, national survey of older adults in the U.S.

1.2. AL

McEwen and colleagues (McEwen, 1998; McEwen & Stellar, 1993) define AL as multisystem physiological wear and tear in response to chronic stress exposure. AL is typically measured by creating an index of several biomarkers (e.g., cholesterol, blood pressure) and physical measures (e.g., waist circumference) collected from the study sample, which represents three physiological systems: cardiovascular functioning, metabolic functioning, and inflammation. Higher scores on the combined index represent more evidence of multisystem dysregulation.

Elevated AL is known to be associated with and predictive of many physical and mental health risks (Guidi, Lucente, Sonino, & Fava, 2021), including cognitive dysfunction and cardiovascular disease (T. E. Seeman, Singer, Rowe, Horwitz, & McEwen, 1997), high blood pressure and type 2 diabetes (Carlsson, Nixon Andreasson, & Wändell, 2011) and poor pregnancy outcomes (e.g., preeclampsia, preterm deliveries, and intrauterine growth restriction) (Hux, Catov, & Roberts, 2014; Hux & Roberts, 2015; Shalowitz et al., 2019). AL is also known to be associated with and predictive of mortality (Guidi et al., 2021; Robertson, Beveridge, & Bromley, 2017; T. E. Seeman, McEwen, Rowe, & Singer, 2001).

There is a natural age gradient for levels of AL associated with aging cells, tissues, and organ systems, whereby even persons with high SEP experience age-related disease and disablement (T. Seeman, Epel, Gruenewald, Karlamangla, & McEwen, 2010; Vineis, Avendano-Pabon et al., 2020; Vineis, Delpierre, et al., 2020). Disparities in AL scores are wider in early adulthood (Richardson, Goodwin, & Hummer, 2021; Rouxel, Chandola, Kumari, Seeman, & Benzeval, 2022). Persons with low SEP experience earlier onsets of age-related health declines and earlier mortality, complicating population health studies of older adults because the samples are composed of unusually healthier persons from poorer SEP and increasingly frail persons from more advantaged social positions, attenuating SEP differentials in health in samples of adults at midlife and older ages.

Social conditions alter human biology and biography to produce socially patterned distributions of disease, accelerated aging, and premature mortality. Chronic stress from social adversity across the life course is posited to result in maladaptive "wear and tear" of developing cells, tissues, and organ systems, deter development of optimal physical health capital during childhood and adolescence and accelerate natural aging processes. Thus, early life adversity may select individuals into health trajectories in middle- and older adulthood that are characterized by disparities in the onset, pace, severity, and comorbidity of age-related chronic disease, functional limitations, and disability. Because biological aging may be decelerated due to changes in environmental stressors, changes in health behaviors, and use of biomedical interventions such as pharmaceuticals to control high blood pressure and high cholesterol, indicate that AL is modifiable (Levine & Crimmins, 2014, 2018).

1.3. SEP and variation in AL

Many studies have shown that low SEP is predictive of variation in AL (Guidi et al., 2021). For example, socioeconomic disadvantage (Gruenewald et al., 2012; McCrory et al., 2019; J. M. Rodriguez et al., 2019), racial inequalities (Currie, Copeland, & Metz, 2019; Duru, Harawa, Kermah, & Norris, 2012; Geronimus, Hicken, Keene, & Bound, 2006), and social support and social integration (T. E. Seeman, Singer, Ryff, Dienberg Love, & Levy-Storms, 2002) have all been shown to predict variation in AL.

There are several potential mechanisms by which social adversity is biologically embedded through exposure to chronic stressors: AL, inflammaging, and epigenetic accelerated aging (EAA). Inflammaging refers to the natural age-related chronic inflammation of molecules, cells, and organ systems which are specific immunological responses to cell debris, microbes, cellular senescence, increased activation of the coagulation system, or immunosenesence (Chung et al., 2019; Franceschi & Campisi, 2014). Interventions target the specific source of inflammation through use of medications such as statins and promoting a healthy gut biome. EAA, AKA epigenetic clocks, recognizes that the epigenome is highly susceptible to acute and chronic environmental stressors, which affect genetic expression and genetic regulation of the biological age of cells, tissues, and organs (McCrory et al., 2020; Vineis, Avendano-Pabon et al., 2020). While EAA is a more precise estimate of biological aging or "weathering", it yields mixed results in predicting morbidity and mortality (McCrory et al., 2020).

AL is higher among Black individuals, Latinxs, and other marginalized racial-ethnic groups due in part to the chronic stress of poverty, racism, and exclusions across the life course (Rodriquez et al., 2021; Thomas Tobin & Hargrove, 2022; Walsemann, Pearson, & Abbruzzi, 2022). Studies have routinely found that Black individuals tend to have higher AL scores than White individuals (Geronimus, Bound, Waidmann, Colen, & Steffick, 2001, 2006, 2019, 2020; Bird et al., 2010; Geronimus, 1992; Merkin et al., 2009; Rodriquez et al., 2021; Thomas Tobin & Hargrove, 2022; Walsemann et al., 2022).

Socioeconomic status is a robust predictor of AL (Beckie, 2012; Dowd, Simanek, & Aiello, 2009; Suvarna et al., 2020; Szanton, Gill, & Allen, 2005). Lifestyle, environmental, and contextual factors pose substantial risks to AL for individuals with fewer economic and social resources (Dowd et al., 2009; Robertson, Benzeval, Whitley, & Popham, 2015; Suvarna et al., 2020). Beyond individual wealth, income, and education, neighborhood socioeconomic status is thought to influence AL, with the accumulating effects throughout the life course evident in later life (Gustafsson et al., 2014).

Some studies have found women to have higher AL scores than men because of greater experiences of social stress, which contradicts somewhat men's biological susceptibility to disease and mortality, compared to women (Mair, Cutchin, & Peek, 2011), though this may vary by the biomarkers included in various AL indices (Beckie, 2012). Other studies have found men to have higher AL than women (Tampubolon & Maharani, 2018), indicating that the gender-AL relationship is unclear. Though gender is usually binarized in AL studies, other research has found that sexual and gender minority individuals tend to have high AL than non-sexual and gender minorities as a result of lifelong marginalization and minority stress (Hoy-Ellis, Kim, & Goldsen, 2020). Studies of sex and gender differences in AL and its sequelae yield mixed results, though there is growing consensus that there are sex-specific drivers of biological aging (McCrory et al., 2020; Tampubolon & Maharani, 2018).

Relationships can be sources of chronic stress as well as buffers of life course stressors. Research has discovered marital concordance in higher AL when a spouse's health changes; men showed greater sensitivity to positive health changes in wives, whereas women are only responsive to husbands' worsening health (Chiu & Lin, 2019). Strained social relationships, including partners, family members, and friends, are associated with high AL scores among younger cohorts but not among older persons (Rouxel et al., 2022). Rouxel et al. (2022) found that strain has a larger effect on AL than social support from the same relationship. Marital disruption from divorce or widowhood has an appreciable durable association with higher AL, findings that reflect joint marital and health selection processes (Rote, 2017).

Though findings regarding the direct effects of social relationships more generally on AL are mixed, there is stronger evidence that social support may moderate the effects of social disadvantage on AL (Wiley, Bei, Bower, & Stanton, 2017). For example, positive social relationships were shown to boost resilience and buffer AL among individuals from economically disadvantaged backgrounds (Singer & Ryff, 1999). Other studies have suggested social support may buffer the impact of racial discrimination and neighborhood poverty on AL in Black youth (Brody, Lei, Chae, et al., 2014; Brody, Lei, Chen, & Miller, 2014). Theoretically, pets may offer the same moderating effect on the relationship between social adversity and AL as social relationships with humans. We elaborate on this in the below section.

1.4. Pet ownership as a moderator of the association between SEP and AL

Because the proportion of older adults in the U.S. population is growing and life expectancy is increasing, it is essential to identify factors that facilitate long-term good health and decrease vulnerability to poor outcomes, particularly among those who experience disproportionately risk of high AL due to adversity and concomitant chronic stress. Understanding whether pet ownership modifies associations between SEP and AL in the context of older adulthood is important given the high prevalence of pets in U.S. households and barriers that older adults face to sustaining pet ownership in older adulthood. For example, pet-exclusionary policies on rental housing may inhibit low-income older adults' ability to maintain housing with their pets (Toohey & Krahn, 2018). Prior research indicates the protective role of pet ownership and/or social relationships with pets on associations between violence exposure and mental health (Hawkins et al., 2019; Hull, Guarneri-White, & Jensen-Campbell, 2022), and minority stressors and mental health (McDonald et al., 2022; McDonald, Murphy, et al., 2021). Thus, the potential role of pet ownership as a moderator of the association between well-established correlates of AL warrants attention.

Despite the potential for pet ownership to offer stress-buffering benefits, some human-animal interactions researchers argue that the impact of pets on human health may vary as a function of an individual's social position and context (Applebaum, MacLean, & McDonald, 2021; Hawkins et al., 2019; McDonald et al., 2022; Mueller et al., 2021). On one hand, it is possible that individuals who belong to marginalized groups may benefit most from the stress-buffering effects of interactions with animals due to their disproportionate experiences of exposure to chronic stress and adversity; at the same time, these same individuals are often subject to agency-limiting contextual factors (e.g., discrimination, constrained resources) that can make pet ownership more challenging, stressful, or even inaccessible (Applebaum, MacLean, & McDonald, 2021). For example, a recent nationally representative study conducted by Mueller et al. (2021) found that for participants who were unemployed, having a dog was associated with twice the odds of having depression compared to those with no dog. For participants who were employed, dog ownership was not associated with any differences in the odds of having depression. Despite what we know about sociodemographic differences in rates of pet ownership and patterns of health and disease, research on associations between pets and human health has rarely considered whether the association between pet ownership and health varies as a function of characteristics of the pet owners themselves.

1.5. The current study

Building on prior theorization and conceptual models that interactions with pets buffer acute stress and support human health by providing social support to their owners (Carter & Porges, 2016; Pendry & Vandagriff, 2020), this study tests whether pet owners have lower AL scores and whether pet ownership moderates the effect of SEP on AL. In this study, we test whether pets may provide a buffering effect on AL while accounting for the competing effects of social inequalities as indicated by SEP. Specifically, we aim to answer the following research questions.

1. Do pet owners have lower repeated measures of AL, compared to non-owners, adjusting for the effects of SEP (i.e., wealth, education, race/ethnicity, gender, and marital status)?
2. Does pet ownership moderate the effects of SEP on AL?
3. Do those who owned pets prior to 2012, but no longer own pets as of the time of the survey, have comparably different AL scores than those who have never owned pets?

2. Methods

2.1. Data

Data analyzed in this study are from the Health and Retirement Study (HRS; (University of Michigan, 2020). The HRS is a longitudinal panel survey, representative of adults, aged 50+, in the United States. The HRS is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The study began in 1992 and is ongoing, with data collection every two years. New participants are continuously enrolled on a rolling basis and are followed until death, with sample sizes around 20,000 each wave. The key independent variable and moderator of interest in this study (pet ownership) was collected via an experimental module administered to approximately 10% of the sample in 2012. The physical and biomarker measures were collected from half-samples, alternating each wave, beginning in 2006. To reconstitute a full sample, scores for 2006 were pooled with scores for 2008 (wave 1), scores for 2010 were pooled with 2012 (wave 2), and scores for 2014 were pooled with 2016 (wave

3). All sociodemographic information was gathered from the RAND HRS Longitudinal file 2018 (RAND Center for the Study of Aging, 2021) and merged with data from the 2012 experimental module and biomarker files from 2006 to 2016. RAND imputed missing data; any missing observations for AL and pet ownership were excluded from the models. The final sample consisted of 3758 observations from 1619 participants. For additional HRS methodological details see (Fisher & Ryan, 2018) and (Documentation | Health and Retirement Study, n.d.).

2.2. Measures

2.2.1. AL

We created an index of AL using a methodology previously established by Stephan and colleagues (Stephan, Sutin, Luchetti, & Terracciano, 2016). We summarize the methodology for the AL index creation here; for more details see Stephan et al., 2016. The AL index is derived from three physical measures (systolic blood pressure, diastolic blood pressure, waist circumference) and five biomarker measures (hemoglobin A1c, high-density lipoprotein, total cholesterol, cystatin C, and C-reactive protein). In this index cardiovascular functioning was assessed with systolic and diastolic blood pressure; metabolism was assessed with HbA1C, high-density lipoprotein cholesterol, total cholesterol, waist circumference, and cystatin C; and inflammation was assessed with C-reactive protein. The scores for high-density lipoprotein were reverse coded to match the direction of risk for the other seven measures (i.e., higher scores equate to higher risk). Next, the biomarker scores were logged, all eight scores were standardized, and the scores for each measure were averaged to create the final AL index score. Higher scores on the AL measure indicate more evidence of multisystem dysregulation and inflammation (Guidi et al., 2021; McEwen, 2000).

2.2.2. Pet ownership

Respondents to the 2012 experimental module were asked, “Do you currently have any pets?” For the main models, “no” responses were coded 0, and “yes” responses were coded 1. Pet types included dogs, cats, small mammals, birds, fish, reptiles, and “other.” For the sensitivity analyses, we constructed a three-category pet ownership variable using another measure from the 2012 experimental module asking those who reported not having any current pets if they had ever had any pets. The constructed variable was coded 0 for never pet owners, 1 for former pet owners, and 2 for current pet owners. While treating pet ownership as time-invariant in longitudinal research has limitations, this information was collected only at one timepoint during the study period and no other data exist to conduct the current study. Given the nature of AL as representative of cumulative chronic stress exposure, there may be a time lag for the effects of pet ownership on stress-related health outcomes (Applebaum et al., 2022). Furthermore, recent research has suggested that short-term interventions could impact longer-term AL (Rosemberg, Granner, Li, & Seng, 2020), thus it is possible that a short pet ownership tenure could influence AL.

2.2.3. Total wealth

Wealth was represented as an aggregate measure of net household assets, which is calculated as the sum of all wealth components (e.g., material possessions, financial assets), less all debt. The continuous measure of wealth was divided into quartiles for analyses (quartile one represents the lowest wealth group, quartile four represents the highest), following methodology predicting morbidity and mortality (Banks, Muriel, & Smith, 2010; Demakakos, Biddulph, Bobak, & Marmot, 2016; Makaroun et al., 2017) and associating assets with end-of-life wealth inequality (J. Poterba, Venti, & Wise, 2018; J. M. Poterba, Venti, & Wise, 2017). The wealth variable was extracted for each wave and allowed to vary by time in the models.

2.2.4. Marital status

Marital/relationship status was collected at each wave. The variable was recoded to 1 for married or partnered, and 0 for all others (i.e., separated, divorced, widowed, or never married). Marital status was time-variant in the models.

2.2.5. Education

Highest level of education earned by each respondent was coded as 1 for less than high school, 2 for high school graduate or equivalent, 3 for some college, and 4 for college and above.

2.2.6. Race/ethnicity

Four categories representing a combination of race and ethnicity were constructed from variables indicating race (coded as the primary race the respondent identified) and Latinx/Hispanic ethnicity (which included Mexican American/Chicano, Puerto Rican, Cuban American, and “other”). The constructed variable included in this study was coded 1 for non-Latinx White, 2 for non-Latinx Black, 3 for non-Latinx other (including Indigenous American, Asian, Native Hawaiian, Pacific Islander, and “other”), and 4 for Latinx/Hispanic.

2.2.7. Gender

Respondent’s gender was coded 1 for man/male and 2 for woman/female. The HRS did not have response options for other sex or gender identities or expressions throughout the study period and thus the gender variable was binarized.

2.3. Analytic procedures

First, we obtain correlations between all study variables. Next, we present weighted mean AL scores by group for each independent variable, as well as percentage of pet owners per group. We then estimate a series of linear mixed models to test (1) the effects of pet ownership on repeated measures of AL over time and (2) the change in effect of pet ownership in AL when progressively considering indicators of SEP in the models. Participant-specific AL scores between 2006 and 2016 were treated as repeated outcome measures, and each model had a random intercept for each individual. We took a staged approach to assess effect modification. First, to test the moderating effect of pet ownership on the relationship between SEP and AL, we estimated interaction terms between pet ownership and each SEP variable (e.g., pet ownership x wealth Q2, etc.). Next, to assess subgroup effects of pet ownership on AL, we estimated a series of stratified models (Vanderweele, 2009) by each sociodemographic subgroup (e.g., the effect of pet ownership on AL among White individuals, adjusted for all study variables except race/ethnicity) for each variable. In these models, we report only the coefficients and p-values for pet ownership, adjusting for all variables in the full sample models except the stratification variable. In addition to all subgroups in the main effects models, we also stratified by age group to test for any cohort effects. Next, sensitivity analyses were conducted to estimate the same series of models with the three-category pet ownership variable to test the effects of both current and former pet ownership on AL. All models are estimated such that level one data are AL measurement occasions (i.e., person waves) nested within level two, which are individual respondents. Model fit was assessed via change in log-likelihood, AIC, and BIC (Gelman & Hill, 2006). Data management, cleaning, and analysis was conducted with Stata version 17; visualizations were conducted with R version 4.0.3 using the lme4 and ggplot2 packages.

3. Results

3.1. Correlations between study variables

We first obtained Pearson correlation coefficients for all study variables for each wave. AL was correlated with all study variables in all waves, except for pet ownership in wave two. See Table 1 for all correlation coefficients.

Table 1
Correlations for study variables by wave.

Variable	1	2	3	4	5	6
Wave 1						
1. AL	–					
2. Pet ownership	−0.07*	–				
3. Wealth	−0.19*	0.03	–			
4. Education	−0.17*	0.0004	0.42*	–		
5. Race/ ethnicity	0.06*	−0.003	−0.25*	−0.21*	–	
6. Gender	−0.11*	0.04	−0.11*	−0.07*	0.02	–
7. Marital status	−0.08*	0.08*	0.31*	0.14*	−0.06*	−0.24*
Wave 2	1	2	3	4	5	6
1. AL	–					
2. Pet ownership	−0.01	–				
3. Wealth	−0.18*	0.06*	–			
4. Education	−0.16*	0.01	0.41*	–		
5. Race/ ethnicity	0.12*	−0.07*	−0.34*	−0.24*	–	
6. Gender	−0.06*	0.03	−0.05*	−0.05	0.002	–
7. Marital status	−0.09*	0.09*	0.28*	0.12*	−0.08*	−0.23*
Wave 3	1	2	3	4	5	6
1. AL	–					
2. Pet ownership	−0.06*	–				
3. Wealth	−0.21*	0.05	–			
4. Education	−0.16*	0.005	0.39*	–		
5. Race/ethnicity	0.08*	−0.05	−0.27*	−0.23*	–	
6. Gender	−0.04	0.04	−0.04	−0.04	0.008	–
7. Marital status	−0.10*	0.11*	0.31*	0.13*	−0.02	−0.23*

*$p < 0.05$.

3.2. Descriptive information

Sample age ranged from 50 to 101 across the three waves. The weighted mean age for wave one was 64.4 ($SD = 9.2$), wave two was 64.8 ($SD = 9.9$), and wave three was 67.7 ($SD = 9.3$).

In Table 2 we present weighted mean standardized AL scores for each group of each sociodemographic characteristic included in the analyses. We also present the proportion of current pet owners (2012) by each subgroup. Approximately half the population represented in HRS had pets in 2012. Current pet owners had lower AL scores than former and never owners across all three waves. See Table 2 for additional descriptive information.

3.3. Effects of pet ownership on AL

Results of linear mixed models are presented in Table 3. Model 1 shows that pet ownership has a significant negative effect on AL when adjusting for time: pet owners are estimated to have lower AL scores, compared to those who do not own pets ($b = -0.05$, $p < 0.05$).

Model 2 reflects fixed effects parameters for wealth quartiles and education. The effect for pet ownership did not change with the inclusion of these covariates ($b = -0.04$, $p < 0.05$). Both wealth and education have significant negative effects on AL, with incremental increases in both magnitude and significance at each level of both variables. Compared to the first quartile of wealth, quartile two has an estimated effect of −0.06 ($p < 0.05$); quartile three has an estimate of −0.08 ($p < 0.001$), and quartile four has an estimate of −0.16 ($p < 0.001$). Compared to those with less than a high school education, those who completed high school but did not continue their education had an estimated effect of −0.04, though this effect was not significant, while those with some college had an estimated effect of −0.09 ($p < 0.05$), and college and above was estimated as −0.16 ($p < 0.001$). In model 3 we add race/ethnicity into the model and the effect for pet ownership decreases to −0.03 and becomes non-significant. The estimates for the other variables carried over from model 2 do not experience notable change, however, the effect for non-Latinx Black racial category

Table 2
Descriptive information for AL scores and pet ownership by groups.

	AL score: weighted mean (SD) (sample n)			% current pet owners (2012)
	Wave 1 (2006, 2008)	Wave 2 (2010, 2012)	Wave 3 (2014, 2016)	
All	−0.09 (0.47) (1144)	−0.07 (0.49) (1523)	−0.08 (0.49) (1326)	51%
Pet ownership				
Current	−0.12 (0.45) (511)	−0.07 (0.49) (698)	−0.10 (0.47) (625)	–
Former	−0.06 (0.47) (537)	−0.06 (0.48) (683)	−0.05 (0.49) (578)	–
Never	−0.08 (0.55) (92)	−0.06 (0.52) (142)	−0.08 (0.59) (123)	–
Wealth				
Q1	0.05 (0.49) (261)	0.06 (0.48) (375)	0.08 (0.48) (315)	48%
Q2	−0.08 (0.41) (270)	−0.01 (0.54) (380)	−0.02 (0.48) (340)	54%
Q3	−0.06 (0.46) (273)	−0.09 (0.48) (380)	−0.04 (0.45) (323)	54%
Q4	−0.26 (0.47) (262)	−0.18 (0.43) (373)	−0.25 (0.49) (326)	49%
Race/ethnicity				
Non-Latinx White	−0.12 (0.46) (878)	−0.11 (0.47) (1036)	−0.11 (0.48) (887)	53%
Non-Latinx Black	0.10 (0.49) (140)	0.12 (0.54) (276)	0.09 (0.54) (245)	27%
Non-Latinx other race	0.004 (0.55) (24)	0.09 (0.64) (45)	−0.10 (0.39) (42)	48%
Latinx	−0.002 (0.44) (90)	0.12 (0.46) (161)	0.08 (0.42) (148)	56%
Gender				
Women	−0.13 (0.47) (756)	−0.11 (0.51) (941)	−0.09 (0.50) (853)	52%
Men	−0.03 (0.45) (387)	0.001 (0.45) (582)	−0.06 (0.46) (473)	50%
Education				
Less than high school	0.07 (0.48) (172)	0.11 (0.46) (242)	0.07 (0.44) (196)	43%
High School	−0.05 (0.45) (410)	−0.01 (0.46) (515)	0.04 (0.46) (451)	54%
Some college	−0.07 (0.47) (299)	−0.06 (0.52) (397)	−0.08 (0.47) (347)	52%
College and above	−0.23 (0.45) (263)	−0.20 (0.46) (369)	−0.24 (0.49) (331)	50%
Marital status				
Married/ partnered	−0.12 (0.45) (752)	−0.09 (0.47) (991)	−0.11 (0.48) (814)	54%
Unmarried/ unpartnered	−0.04 (0.49) (314)	−0.02 (0.52) (518)	−0.02 (0.50) (489)	46%

Data source: Health and Retirement Study, 2006–2016, weighted estimates

(compared to non-Latinx White) significantly increased AL scores by 0.12 units ($p < 0.001$). The change in estimated trajectories of AL by pet ownership group between model 2 and model 3 is displayed visually in Fig. 1.

In model 4 we add gender and marital status, which both have a significant effect on AL: women, compared to men, are predicted to have lower AL scores ($b = -0.11$, $p < 0.001$), and those who are married or

Table 3
Linear mixed-effects model estimates for the effects of predictors on repeated measures of AL scores ($n = 1619$; 3758 observations).

	Estimate (S.E.)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed effects					
Intercept	−0.02 (0.02)	0.12*** (0.03)	0.06^ (0.04)	0.15*** (0.04)	0.10* (0.05)
Wave (1=ref)					
2	0.03* (0.01)	0.04** (0.01)	0.03** (0.01)	0.03* (0.01)	0.03 (0.01)
3	0.04** (0.02)	0.05*** (0.01)	0.04*** (0.01)	0.04* (0.01)	0.04* (0.01)
Pet ownership	−0.05* (0.02)	−0.04* (0.02)	−0.02 (0.02)	−0.02 (0.02)	0.08 (0.08)
Wealth (Q1=ref)					
Q2		−0.06** (0.02)	−0.05* (0.02)	−0.04* (0.02)	−0.05 (0.03)
Q3		−0.09*** (0.02)	−0.06* (0.02)	−0.05*(0.02)	−0.03 (0.03)
Q4		−0.16*** (0.03)	−0.13*** (0.03)	−0.12*** (0.03)	−0.11** (0.04)
Education (<h.s.=ref)					
High school		−0.04 (0.03)	−0.02 (0.03)	−0.02 (0.03)	−0.01 (0.04)
Some college		−0.08* (0.03)	−0.07* (0.03)	−0.07* (0.03)	−0.10* (0.05)
College and above		−0.16*** (0.04)	−0.15*** (0.04)	−0.15*** (0.04)	−0.13** (0.05)
Race/ethnicity (non-Latinx White=ref)					
Non-Latinx Black			0.13*** (0.03)	0.12*** (0.03)	0.14*** (0.04)
Non-Latinx other			0.05 (0.06)	0.05 (0.06)	0.07 (0.08)
Latinx			0.04 (0.04)	0.04 (0.04)	0.09 (0.05)
Woman (man = ref)				−0.10*** (0.02)	−0.08** (0.03)
Married/partnered (unmarried/unpartnered = ref)				−0.06*** (0.02)	−0.03 (0.03)
Pet x wealth Q2					0.01 (0.05)
Pet x wealth Q3					−0.03 (0.05)
Pet x wealth Q4					0.00 (0.06)
Pet x high school educ					−0.05 (0.07)
Pet x some college					0.08 (0.07)
Pet x college and above					−0.03 (0.07)
Pet x Black					−0.01 (0.07)
Pet x other race					−0.07 (0.13)
Pet x Latinx					−0.09 (0.07)
Pet x women					−0.05 (0.04)
Pet x married/partnered					−0.06 (0.04)
Random effects					
Intercept variance (S.D)	0.13 (0.36)	0.12 (0.35)	0.12(0.35)	0.12 (0.34)	0.12 (0.35)
Goodness of fit					
Log likelihood	−2240.05	−2212.46	−2210.49	−2202.45	−2218.40
AIC	4492.10	4448.92	4450.98	4438.89	4492.80
BIC	4529.49	4523.69	4544.46	4544.82	4667.28

Notes: Source: Health and Retirement Study, 2006–2016
^$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

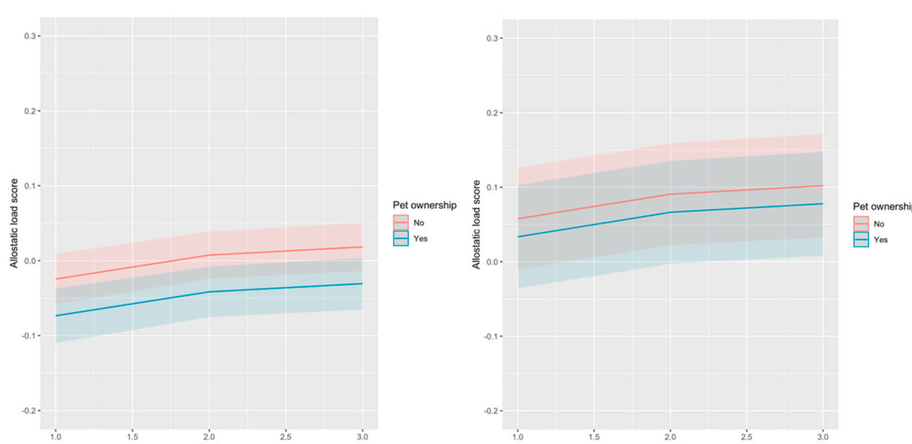

Fig. 1. AL score for pet owners (blue) and non-owners (red) over time: the left panel is adjusted for wave, education, and wealth; the right panel is adjusted for wave, education, income, wealth, and race/ethnicity. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

partnered, compared to unmarried/unpartnered individuals, also have lower predicted scores ($b = -0.07$, $p < 0.001$). The effect of pet ownership was not significant in this model ($b = -0.02$).

In the final model (model 5), we test the moderating effect of wealth, education, race/ethnicity, gender, and marital status on the effect of pet ownership on allostatic load scores by including interaction terms. All interactions in the model were non-significant, indicating no evidence of moderation.

3.4. Moderating role of pet ownership on associations between AL and social position: subgroup analyses

Table 4 displays models stratified by sociodemographic characteristics. Pet ownership was significant in the models for three subgroups: high school education ($b = -0.08$, $p < 0.05$), some college education ($b = 0.09$, $p < 0.05$), and those aged 80+ ($b = 0.12$, $p < 0.05$). Among those who reported high school education, pet owners had lower AL scores than non-owners, whereas, among those who reported some college education, pet owners had higher AL scores. Among those aged 80+, pet owners had higher AL scores than non-owners.

3.5. Sensitivity analysis

To test whether former pet ownership also had an effect on AL, we estimated a series of models with pet ownership in three categories: never pet owner, former pet owner, and current pet owner (Table 5). The first model, adjusted for wave, indicated that current pet ownership, but not former pet ownership, had a significant, negative effect on AL ($b = -0.08$, $p < 0.05$). The coefficient for former pet ownership was negative, but it was not statically significant ($b = -0.04$). See Fig. 2.

With the addition of wealth and education the effect of current pet ownership on AL also became non-significant. The direction of the coefficient indicated a modest negative relationship between pet ownership and AL throughout the models, while the coefficient for former pet ownership became positive with the addition of race/ethnicity variables in model 3.

Table 4
Linear mixed-effects model estimates for the effects of pet ownership on repeated measures of AL scores, stratified by sociodemographic variables.

Subgroup	Estimate (S.E.)
By wealth	
First quartile	−0.02 (0.04)
Second quartile	−0.02 (0.04)
Third quartile	−0.02 (0.04)
Fourth quartile	−0.01 (0.04)
By education	
Less than high school	−0.05 (0.05)
High school	−0.08* (0.04)
Some college	0.09* (0.04)
College and above	−0.03 (0.04)
By race/ethnicity	
Non-Latinx White	−0.01 (0.02)
Non-Latinx Black	0.002 (0.07)
Non-Latinx other	−0.08 (0.13)
Latinx	−0.07 (0.06)
By gender	
Woman	−0.02 (0.03)
Man	−0.004 (0.03)
By marital status	
Married/partnered	−0.03 (0.02)
Unmarried/unpartnered	0.01 (0.04)
By age	
<65	−0.02 (0.03)
65-79	−0.02 (0.03)
80+	0.12* (0.06)

Notes: Source: Health and Retirement Study, 2006–2016
*$p < 0.05$.
Adjusted for wave, wealth, education, race/ethnicity, gender, and marital status in all models, excluding the stratification variable.

Table 5
Linear mixed-effects model estimates for the effects of predictors on repeated measures of AL scores, three-category pet ownership (n = 1619; 3758 observations).

	Estimate (S.E.)			
	Model 1	Model 2	Model 3	Model 4
Fixed effects				
Intercept	0.01 (0.04)	0.12** (0.04)	0.04 (0.05)	0.14** (0.05)
Wave (1=ref)				
2	0.03* (0.01)	0.04** (0.01)	0.03* (0.01)	0.03* (0.01)
3	0.04** (0.01)	0.05*** (0.01)	0.04** (0.01)	0.04* (0.01)
Pet ownership (never owner=ref)				
Former owner	−0.04 (0.04)	−0.01 (0.04)	0.02 (0.04)	0.01 (0.04)
Current owner	−0.08* (0.04)	−0.05 (0.04)	−0.01 (0.04)	−0.01 (0.04)
Wealth (Q1=ref)				
Q2		−0.06** (0.02)	−0.05* (0.02)	−0.04* (0.02)
Q3		−0.09*** (0.02)	−0.06* (0.02)	−0.05* (0.03)
Q4		−0.16*** (0.03)	−0.13*** (0.03)	−0.12*** (0.03)
Education (<h.s.=ref)				
High school		−0.04 (0.03)	−0.02 (0.03)	−0.02 (0.03)
Some college		−0.08* (0.03)	−0.07* (0.03)	−0.07* (0.03)
College and above		−0.16*** (0.04)	−0.15*** (0.04)	−0.15*** (0.04)
Race/ethnicity (non-Latinx White=ref)				
Non-Latinx Black			0.13*** (0.03)	0.13*** (0.03)
Non-Latinx other			0.05 (0.06)	0.05 (0.06)
Latinx			0.04 (0.04)	0.04 (0.04)
Woman (man = ref)				−0.10*** (0.02)
Married/partnered (unmarried/ unpartnered = ref)				−0.06** (0.02)
Random effects				
Intercept variance (S.D)	0.13 (0.36)	0.12 (0.35)	0.12 (0.35)	0.12 (0.34)
Goodness of fit				
Log likelihood	−2241.81	−2214.81	−2212.74	−2204.78
AIC	4497.61	4455.62	4457.48	4445.55
BIC	4541.23	4536.63	4557.18	4557.72

Notes: Source: Health and Retirement Study, 2006–2016
^$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

4. Discussion

In this study, we aimed to evaluate whether, and to what extent, pet ownership was associated with AL in a national sample of U.S. adults aged 50+. We also tested whether the effect of pet ownership on AL persisted when accounting for SEP, and finally, whether pet ownership moderated the relationship between SEP and AL. We found that pet ownership had a significant, negative relationship with AL: those who confirmed pet ownership in 2012 tended to have lower AL scores between 2006 and 2016 than those who did not own pets. This finding suggests that owning pets may have benefits that are associated with lower AL scores. For example, pets could play a role in stress relief for their owners, which is consistent with previous research (e.g. (Carter & Porges, 2016; Pendry & Vandagriff, 2020),). In the main models, the effect of pet ownership on AL persisted when adjusting the model for wealth and education; however, the effect became non-significant with the addition of the race/ethnicity variables. In the stratified models, we found that pet ownership moderated the effects of education and age on

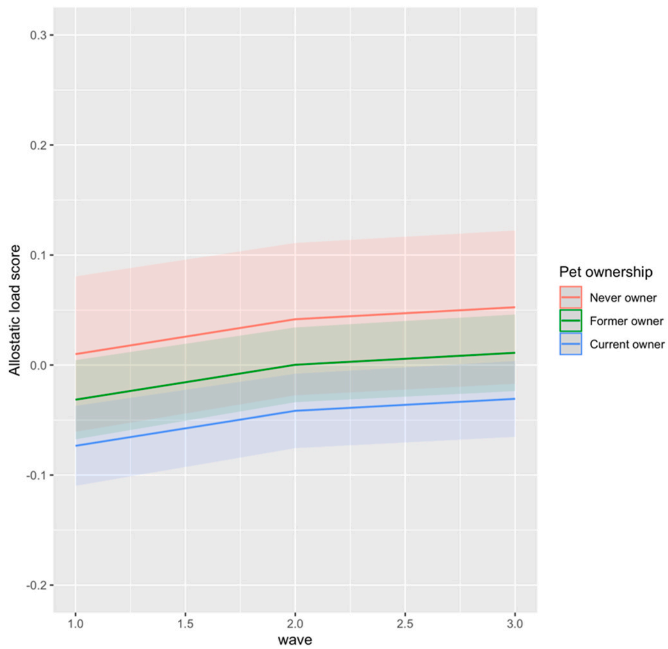

Fig. 2. AL score for three-categories of pet ownership over time.

AL. We discuss potential explanations for these findings below.

Pets may provide benefits that are associated with lower AL; however, identities of pet owners, and their individual and social resources and experiences, may modify how pets impact health and/or counteract chronic stress. This suggests that either the magnitude of the effect of pet ownership is insufficient in the face of increased chronic stress, or in some contexts the stress buffering effect may not be exerted. For example, pets may be a net benefit to health in moderately stressful contexts, but less so in high stress environments, where pets could potentially even become an added stressor or burden. This is reflected in the age-stratified models, where we found that the AL scores of pet owners were higher than non-owners for those aged 80+. For example, affordable rental housing can be difficult to obtain with a pet, as many properties either restrict pets altogether or charge additional fees and fines for pets (Applebaum, Horecka, Loney, & Graham, 2021; Power, 2017; Rose, McMillian, & Carter, 2020; Toohey & Krahn, 2018; Toohey & Rock, 2019). This is an especially salient issue for older adults, who may face barriers to aging in place with their pets beyond finding and maintaining pet-friendly housing in the community, such as the inability to walk larger dogs or lift heavy bags of cat litter (Applebaum, Ellison, Struckmeyer, Zsembik, & McDonald, 2021; McLennan, Rock, Mattos, & Toohey, 2022; Toohey, Hewson, Adams, & Rock, 2017; Toohey & Krahn, 2018; Toohey & Rock, 2019). Taken together, the responsibility of pet caregiving could become stressful for older adults. However, other research has suggested that the comfort and support provided by a pet may be especially salient for those facing adversity (Applebaum, MacLean, & McDonald, 2021), such as LGBTQ + individuals (McDonald, Murphy, et al., 2021; Muraco, Putney, Shiu, & Fredriksen-Goldsen, 2018; Schmitz, Carlisle, & Tabler, 2021; Schmitz, Tabler, Carlisle, & Almy, 2021), individuals experiencing adverse family or domestic circumstances (Applebaum & Zsembik, 2020; Collins et al., 2018; Hawkins et al., 2019; McDonald et al., 2015, 2017), and individuals experiencing homelessness (Irvine, 2012; Kerman, Gran-Ruaz, & Lem, 2019). Relatedly, previous research regarding the relationship between psychosocial resources and AL has been mixed, implying that the potential role of protective resources in attenuating AL, such as social support, is unclear (Wiley et al., 2017).

There was no evidence of subgroup moderating effects for wealth quartiles, racial and ethnic groups, gender, or marital status. Pet ownership did moderate the effect of education on AL in the stratified models. Specifically, among those with a high school education, pet owners had lower AL, whereas, among those with some college education, pet owners had higher AL. Previous research has consistently shown a negative relationship between educational attainment and AL (Howard & Sparks, 2016), however, more research is needed to explicate our varying results related to pet ownership by education subgroups. Based on the theoretical implications that pets may have for stress buffering and health outcomes, supporting pet ownership for marginalized and low-resourced individuals could be advantageous, but it is unlikely to result in population health improvements without addressing the underlying causes of health disparities such as racism (Phelan & Link, 2015; Williamset al., 2019) and socioeconomic inequalities (Link & Phelan, 1995; Phelan, Link, & Tehranifar, 2010).

Although this study did not find substantial differences in economic resources between pet owners and non-owners, other studies have indicated that dog owners may have higher income than those who do not own dogs (Applebaum, Peek, & Zsembik, 2020), suggesting that dog owners may be better able to afford medical care than non-owners. However, there is some research showing that some pet owners may be less likely to access timely healthcare (Applebaum, Adams, Eliasson, Zsembik, & McDonald, 2020; Canady & Sansone, 2019; Polick et al., 2021), particularly those with fewer economic resources, less social support, and those who are highly attached to their pets. Importantly, this question has only been addressed among pet owners and has not been assessed by comparing pet owners and non-owners, which should be a topic of future inquiry.

Findings in this study may also help explain some of the conflicting previous findings regarding pet ownership and health from population surveys. Many of the previous studies on this topic neglected to consider confounding factors in their analyses, and those that did include socioeconomic factors often left out race and ethnicity. Considering the well-known, profound effects that chronic stress from racism, other structural inequalities and interpersonal adversities have on health, it is pertinent to consider these factors in relation to any generalizations regarding pet ownership and health. Pets may have a stress-buffering effect for some, or even most owners, but the effect is not likely of a magnitude that is detectable. It is also important to consider variations in relationships with pets, as many factors related to the animal and the interactions between humans and animals may have implications for owner mental health (K. E. Rodriguez, Herzog, & Gee, 2021). Future research should consider variation in relationships with pets (e.g., levels of attachment and bonds, who in the household cares for the pet), as well as the impact of SEP, when drawing conclusions about pet ownership and health. Furthermore, it is difficult to assess whether those who do not own pets may benefit from them, as many individuals may choose not to own pets for various practical and emotional reasons (Chur-Hansen, Winefield, & Beckwith, 2008). While it is unethical to randomly assign pet ownership to individuals in a research setting, future research may consider a natural experimental approach to assessing the impact of the acquisition of a pet on AL.

Other explanations for our findings include the potential indirect effect of pet ownership on AL through mediational pathways, including well-established predictors or moderators of AL. For example, prior studies indicate that pets may promote social connection with other humans (McDonald, Matijczak, et al., 2021; McNicholas & Collis, 2006; McNicholas et al., 2005; Wood, Giles-Corti, & Bulsara, 2005a, 2005b, 2017). Therefore, it is possible that pet ownership may impact AL by increasing the likelihood of an individual forming positive social connections, such as relationships with potential romantic partners (Gray, Volsche, Garcia, & Fisher, 2015). In turn, the benefits associated with marriage or intimate partnerships may facilitate lower AL. Alternatively, there is emerging evidence that caring for pets may impede or negatively impact dating and intimate relationship behavior, particularly when pet-related routines and/or pets' behavioral challenges or health needs prevent their owners from engaging in social activities (Graham, Milaney, Adams, & Rock, 2019; McDonald, Matijczak, et al., 2021). To better understand the mechanisms through which pet ownership impacts human health and wellbeing over time, it is important that future studies employ longitudinal methods (i.e., repeated measures) that allow for the assessment of reciprocal relationships between pet ownership, SEP, social relationships, and indicators of health.

4.1. Limitations

This study is not without limitations. First, while AL was measured at three timepoints between 2006 and 2016, pet ownership was only measured once, in 2012, and pet species was not considered. Bonds between humans and pets are hypothesized to rely on neuroendocrine pathways and molecules that play critical roles in mammalian emotions and social behavior; thus, it may be beneficial for future studies to differentiate whether there are differences in the relationship between pet ownership and AL across pet species as the effects may be more pronounced among those who care for and reside with mammals. In terms of pet ownership tenure, the majority (62%) of pet owners in this sample reported having their pet for six or more years as of 2012, therefore their time one measurement of AL (2006 or 2008) would have been during their pet-owning time. However, the continuity of pet ownership among those who owned pets in 2012 is unknown. Rates of pet ownership tend to decrease between middle age and older age (Applebaum, Peek, & Zsembik, 2020; Bibbo et al., 2019), therefore it is possible that those who owned a pet in 2012 did not continue to own a pet beyond then. It is also important to note that those who did not own a pet in 2012 could have previously owned a pet at any point, and/or they could have acquired a pet after 2012. Only 13% of those who did not own a pet in 2012 reported that they had never owned one. Additionally, because AL represents the *accumulated* physical consequences of chronic stress exposure, a brief pet ownership tenure, regardless how stress-relieving that relationship may have been, would be unlikely to have a detectable effect on AL.

Another limitation in the data that should be noted is the pattern of collection of the measures that make up the AL index score. The Health and Retirement Study collects biomarkers and physical measures during enhanced, face-to-face interviews alternating 50% of the overall sample each wave. Because of this pattern of collection, the first half of the sample had AL scores for 2006, 2010, and 2014, while the other half had scores in 2008, 2012, and 2016. In order to reconstitute a full sample, data from 2006 were pooled with 2008, 2010 with 2012, and 2014 with 2016. It should be noted that circumstances during those time periods could have reflected differently among half-samples, depending on the timing of collection. For example, those whose time one measure of AL was collected in 2008, as opposed to 2006, may have been impacted by the Great Recession, an event that many Americans found to be extremely stressful.

Our analytic approach also has limitations that should be noted. In particular, we employed both regression interaction and stratified models to assess evidence of moderation. The interaction terms did not suggest any moderation effects; however, the stratified models suggested that pet ownership was a significant moderator in the relationship between both age and AL, and education and AL. Though our moderation analyses were based on theoretical and conceptual frameworks, because we tested for effect modification across all SEP groups, there is some risk of spurious results (van der Weele & Knol, 2014). Furthermore, as we were limited by the use of a secondary dataset, (1) we were unable to control for all possible confounders in the moderation analyses and thus our results could be biased, and (2) the study may not have been sufficiently powered to detect effect modification in some of the subgroups (van der Weele & Knol, 2014).

Finally, we highlight the limitations and challenges associated with making assumptions about heterogeneous groups based on broad sociodemographic groupings. This is particularly important to consider with respect to racial and ethnic groups, as there is great variability in identity and experience across the groupings in the current study. For example, a Hispanic/Latinx category was created and analyzed as a "catch-all" for individuals who identified as Hispanic and/or Latino/a/x. However, there is great variability in culture and lived experiences across Hispanic and Latinx subgroups (e.g., Guatemalan vs. Mexican, Afrolatinidad, and other multi-ethnic/racial experiences) that have notable implications in relation to our dependent variable of AL (Salazar et al., 2016). These differences cannot be meaningfully captured with the measurement approach employed in the larger study. Similarly, the identities grouped in the "non-Latinx other" group are diverse, and this categorization does not adequately or meaningfully capture the complexity of the represented identities and experiences associated with their social location.

5. Conclusion

In this study, we found that pet owners tended to have lower AL scores than non-owners, but the effect was not significant when accounting for some of the sociodemographic characteristics associated with varying experiences of chronic stress. Pets may modify the association between SEP and AL; however, the magnitude of the effect may not be sufficient to counteract the profound impact of social marginalization and disadvantage. Alternatively, individuals who belong to social groups who tend to experience less chronic stress may be more likely to have pets than those from groups with higher chronic stress due to access to pet ownership and associated resources. Increasing support for pet ownership may promote health among marginalized groups; however, it must be paired with broader efforts to increase overall health equity by undressing the underlying causes of population health disparities.

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Author credit statement

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Shelby E. McDonald: writing.

Barbara A. Zsembik: writing.

Ethical statement

I confirm that this manuscript has not been submitted for publication with any other journal or publishing company.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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