



When dogs react: The role of caregiver factors and fear/anxiety in reactive and aggressive manifestations

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ABSTRACT

Reactive/aggressive manifestations (R/AMs) are a problematic behavior that significantly affects the well-being of both dogs and their caregivers, reducing their quality of life and undermining the stability of the human–animal bond. This cross-sectional study (N = 730) focused primarily on caregiver-related characteristics associated with R/AMs in dogs, followed by an analysis of the contribution of fear/anxiety. Data were collected through an online questionnaire. Starting from a broad set of variables related to the dog (e.g., age), caregiver sociodemographic characteristics (e.g., gender), intrapersonal variables (e.g., mental health), interpersonal variables (e.g., attitudes), and caregiving and management practices (e.g., professional training), Pearson correlations were calculated between all variables and this problematic behavior. All variables that were significantly correlated with R/AMs were included in multiple linear regression models to identify the most relevant predictors from this broad set of factors. The results highlight the role of caregiver-dog interpersonal dynamics and the relevance of fear/anxiety in the R/AMs. Younger dogs, those cared for by male caregivers, dogs whose caregivers reported higher perceived caregiving costs and higher caregivers stress levels, more positive attitudes toward aversive training methods, and a lower ability to recognize chronic pain, were described as showing higher levels of R/AMs. Together, these variables explained 15.8 % of the variance in R/AMs. When fear/anxiety was added to the model, the amount of explained variance increased substantially, with the final model accounting for 41 % of the variability in this problematic behavior. These findings emphasize the importance of the caregiver-dog relationship in understanding R/AMs and suggest that fear/anxiety is a core underlying component of this problematic behavior. Behavioral interventions for R/AMs should address not only the dog's behavior and emotional state, but also caregiver-related factors. Consideration should be given to the use of strategies that improve caregiver's knowledge of indicators of pain and discomfort in dogs, encourage the use of reward-based training, and support reduced caregiving costs.

1. Introduction

Although the term “canine aggression” has been widely used in the literature to describe these behaviors (e.g., Gobbo and Zupan, 2020; Orritt et al., 2015; Podberscek and Serpell, 1997), more recent research has increasingly adopted the concept of reactivity to capture a broader spectrum of behavioral responses that may or may not include aggression (e.g., Somppi et al., 2022; Stephens-Lewis et al., 2022). In this

study, we refer to these problems as reactive/aggressive manifestations (R/AMs), in line with this more integrative perspective. They are a highly prevalent problem, affecting approximately 43 % of dogs (Lima, 2023). This problematic behavior significantly impacts the well-being of both dogs and their caregivers, compromising their quality of life and the stability of the human–animal relationship (e.g., Barcelos et al., 2023a; Barcelos et al., 2023b; Barrios et al., 2022; Buller and Ballantyne, 2020; Love, 2021).

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R/AMs are often associated with negative emotional states, such as fear/anxiety (F/A), and can be exacerbated by environmental (e.g., urban settings), medical (e.g., pain), or caregiver-related factors (e.g., Mills et al., 2020; Sherman and Mills, 2008).

Mikkola et al. (2021) found that aggression is more frequent in male dogs, increases with age, and is strongly associated with fear, with highly fearful dogs being five times more likely to display aggressive manifestations. However, the extent to which fear explains variability in R/AMs remains unclear. In addition to fear, chronic pain or physical discomfort - particularly musculoskeletal pain has been identified as a major contributor to behavioral problems in dogs (e.g., Morey and Grau, 2013; Mills et al., 2020), though its specific role in R/AMs is still underexplored. In this study, we focused primarily on the influence of caregivers, but we also investigated the role of fear and chronic pain in reactivity (e.g., barking, leash pulling) that includes aggressive manifestations and is typically fear-based, as opposed to frustration- or excitement-driven responses, where fear is not expected to play a major role. In the literature, some overlap between frustration and aggression has been acknowledged, since behaviors such as barking or leash pulling may occur in both contexts. However, in the present study we explicitly focused on reactivity with aggressive manifestations (R/AMs), distinguishing it from frustration- or excitement-based reactivity (Lenkei et al., 2018; McPeake et al., 2021; Wilson et al., 2024).

Caregiver-related factors also appear to play a crucial role: higher levels of caregiver anxiety or depression have been associated with an increased frequency of behavioral issues, including reactivity and aggression (Barcelos et al., 2023a; Clarke and Loftus, 2023; Hunt et al., 2012). Furthermore, caregivers' attachment styles may influence how dogs' express aggression, with avoidant attachment linked to aggression toward the caregiver and anxious attachment associated with lower stranger-directed aggression (Gobbo and Zupan, 2020).

The influence of the caregiver's personality has also been investigated, with the trait of neuroticism emerging as a risk factor for R/AMs in dogs (Dodman et al., 2018; Gobbo and Zupan, 2020; Podberscek and Serpell, 1997). In contrast, caregiver extraversion has been associated with lower reactivity in dogs (Dodman et al., 2018; Gobbo and Zupan, 2020). Conscientiousness and agreeableness have also been linked to fewer R/AMs (Dodman et al., 2018).

Some authors suggest that caregiver empathy increases perceived reactivity in dogs (Szánthó et al., 2017), while others argue that it promotes calm and secure responses thus reducing reactivity (Pirrone et al., 2015). The nature of this relationship remains unclear and requires further investigation. Anthropomorphism, by influencing how caregivers perceive and manage their dogs, may play a significant role in dogs' R/AMs (Mota-Rojas et al., 2021; Orritt et al., 2015; Pirrone et al., 2015; Szánthó et al., 2017), but empirical evidence on this association remains limited.

The caregiver-dog bond has been linked to behavioral problems, with higher perceived caregiving costs associated with more conflicting behaviors (Neessen, 2013). Perceived costs include not only financial expenses (e.g., My dog costs too much money), but also increased workload (e.g., My dog makes too much mess), the need to forgo certain activities (e.g., How often does your dog stop you doing things you want to?), and questions related to the caregiver's enjoyment of having a dog (e.g., There are major aspects of owning a dog I don't like). Conversely, greater emotional closeness related to lower emotional reactivity in dogs (Somppi et al., 2022). However, research in this area remains limited and further evidence is needed.

Dodman et al. (2018) found weak but significant associations between favorable attitudes towards aversive training and greater severity of aggression directed at both caregivers and strangers, suggesting a possible link between such attitudes and the intensity of behavioral problems.

No studies were found that directly link attitudes toward companion animals (e.g., Templer et al., 1981), the comfort provided by the dog (e.g., Zasloff and Kidd, 1994), and the caregiver's ability to recognize

chronic pain (Batista et al., 2025) to R/AMs in dogs. This study also adopts a One Health perspective, recognizing the interconnectedness of human and animal health and welfare, and the importance of considering caregiver-related factors when addressing behavioral problems in dogs. The main objective is to analyze, in an integrated manner, a broad set of variables that have mostly been examined in isolation. Additionally, it aims to assess the extent to which fear/anxiety and chronic pain are associated with reactive/aggressive manifestations (R/AMs), thereby providing a more comprehensive understanding of their key predictors.

Based on the reviewed literature we expect higher levels of reactive/aggressive manifestations when dogs experience chronic pain or physical discomfort (Mills et al., 2020; Morey and Grau, 2013), when caregivers show elevated depression (Hunt et al., 2012; Barcelos et al., 2023a; Clarke and Loftus, 2023), when caregivers present avoidant attachment styles (Gobbo and Zupan, 2020), or higher neuroticism (Dodman et al., 2018; Podberscek and Serpell, 1997). By contrast, lower levels are expected when caregivers display extraversion, conscientiousness, agreeableness (Dodman et al., 2018; Gobbo and Zupan, 2020), or greater emotional closeness (Somppi et al., 2022). Additional risk factors may include higher anthropomorphism (Mota-Rojas et al., 2021; Orritt et al., 2015; Pirrone et al., 2015; Szánthó et al., 2017), greater perceived caregiving costs (Neessen, 2013), and favourable attitudes toward aversive training (Dodman et al., 2018).

2. Methods

2.1. Ethical approval

The study was approved by the Ethics Committee (Ref.: 22170). Informed consent was obtained from all participating caregivers prior to data collection. Participants were assured of the voluntary nature of their involvement, their right to withdraw at any time, and the anonymity and confidentiality of their responses.

2.2. Participants

The sample was non-probabilistic and based on convenience, comprising 730 caregivers (95.2 % women), with a mean age of 35.5 years (SD = 9.8; range: 18–82 years). Data were collected through a Portuguese-language online questionnaire (Google Forms), distributed via social media and veterinary medical centers between 16 October 2023 and 24 March 2024.

2.3. Instruments

The questionnaire comprised four sections: 1) control questions; 2) companion dog questionnaire; 3) caregiver characteristics; and 4) socio-demographic data. In the control section, caregivers were asked about their legal age, whether they were the dog's primary carer, and if they had lived with their dog for at least one year. The Companion Dog Questionnaire (based on the behavior questionnaire of the British Small Animal Veterinary Association, Horwitz and Mills, 2012) followed, asking about the dog's age, how long had he lived with its owner, where he usually stays during the day, where he sleeps at night, how many hours he spends without human company, walk frequency, veterinary visits, health issues, osteoarthritis diagnosis, radiography with sedation, professional training, basic behaviors, ability to perform tricks, and how disobedience was handled (open-ended). To assess F/A, we used four items: "Is fearful, and it is difficult to be with them in certain environments"; "Is very anxious"; "Is constantly alert when outside"; and "Is constantly alert at home". To assess R/AMs, we used five items: "Reacts by barking and pulling on the leash when it detects another dog"; "reacts by barking and pulling on the leash when an unfamiliar person approaches (adults and/or children)"; "sometimes shows aggressive behaviors"; "it is difficult to live with my dog because of its behavior"; "it is

difficult to walk my dog because of its behavior". These items were presented together as a block specifically referring to reactivity/aggression. Internal consistency analysis indicated that they formed a coherent set (Cronbach's $\alpha = 0.789$), suggesting that participants perceived them as reflecting the same underlying construct of reactive/aggressive manifestations. Responses were rated on a scale from 0 = not at all to 10 = very much. We did not use the C-BARQ because this study is part of a larger project in which we also investigated the factors influencing fear/anxiety, separation-related problems, and excess energy/hyperactivity in dogs. In the Portuguese version of the C-BARQ, fear and aggression are combined within the same subscale.

The caregiver characteristics section assessed empathy (The Animal Empathy Scale (AES) was used to assess empathy towards pets, [Emauz et al., 2016](#)); attitudes toward animals (Pet Attitude Scale was employed, [Templer et al., 1981](#); [Varela, 2021](#)); the caregiver-dog bond Monash Dog-Owner Relationship Scale (MDORS) assessed the dog-caregiver bond through three subscales: perceived costs, perceived emotional closeness, and dog-owner interaction ([Dwyer et al., 2006](#); [Guimarães, 2017](#)); anthropomorphism (Anthropomorphism Scale was translated and back translated to measure the tendency to anthropomorphize, [Antonacopoulos and Pychyl, 2008](#)); emotional comfort provided by the dog (The Comfort from Companion Animals Scale assessed the emotional comfort provided by the companion dog, [Guimarães, 2017](#); [Zasloff and Kidd, 1994](#)); attitudes toward aversive training (The Attitude to Training Questionnaire was translated and back translated ([Dodman et al., 2018](#)); ability to perceive chronic pain (Chronic Pain Perception Scale ([Batista et al., 2025](#)), personality (Big Five Personality Inventory, [Rodrigues and Gomes, 2022](#)); attachment style (Adult Attachment Scale, [Canavarro et al., 2006](#)) and mental health (Depression Anxiety and Stress Scale ([Pais-Ribeiro et al., 2004](#)). Lastly, participants provided information on gender, age, residence, level of education, and household income.

2.4. Data analysis

Scale scores were calculated as the mean of the items, after reverse-coded items were recoded. All measures showed acceptable values for standardized Cronbach's alpha (α) (see [Table S1](#) of the [supplementary material](#)).

Qualitative variables were recoded into dummy variables. In all dummy variables, the reference group was coded as 0, the comparison category as 1, and all remaining categories as 0 ([Marôco, 2021](#)), ([Table S1](#)).

To identify the variables most strongly associated with the problematic behavior index — and thus potential candidates for multiple linear regression models (MLRM) — Pearson correlations were first calculated between all variables (questions/scales), and the R/AMs index ([Table S1](#)). Following the guidelines of [Marôco \(2021\)](#), only variables significantly correlated with SRPs were included in the MLRM (except for the dummy variables "intact male", "spayed female", and "neutered male", which were excluded because the number of cases was considerably lower than for the other variables, significantly reducing the sample size in the MLRM). To avoid multicollinearity, the subscales were used without including the total scale score simultaneously (e.g., stress, anxiety, and depression subscales from the Depression, Anxiety and Stress Scale).

In the MLRM, as this was an exploratory analysis without a predefined theoretical model, the Stepwise method was initially used to identify the model that best fit the data. After identifying the model, statistical assumptions were assessed, and variables showing signs of multicollinearity were removed.

The predictor variables were then organized into five blocks, and new MLRM were estimated using the Enter method with sequential entry: first, variables related to the dog; second, sociodemographic variables; third, intrapersonal variables; fourth, interpersonal variables; and fifth, variables related to caregiving and management. This

approach aimed to identify which group of variables contributed most to explaining R/AMs.

A new MLRM was then estimated, introducing F/A as an additional predictor. To prevent endogeneity problems due to simultaneity — that is, situations in which an explanatory variable is correlated with the model error, potentially biasing and compromising the consistency of the estimates — variables that simultaneously influenced both F/A and R/AMs were removed from the final model [using the same set of variables from this study, the predictors of F/A are the dog's age, caregiver stress, perceived caregiving costs, attitudes towards aversive training, the annual average number of veterinary consultations, knowing four basic training behaviors, and being on medication ([Batista et al., submitted](#))].

3. Results

[Table S1](#) ([supplementary material](#)) presents the correlations between the variables under study and R/AMs, as well as the internal consistency (Cronbach's alpha) of each scale. Contrary to expectations, the dummy variable related to osteoarthritis (chronic pain) showed negative correlations with CR/A ($r = 0.053$, P -value 1-tailed = 0.026, $n = 729$). A similar pattern was observed for the "health problems" variable. A closer analysis revealed that most of these dogs were under medication (83 %; $\chi^2 = 86.720$, $P < .001$). It is possible that this indicates that in these dogs, pain or discomfort associated with osteoarthritis or other health conditions was well managed.

3.1. Correlations

Younger dogs ($r = -0.187$, $p < 0.001$, $n = 730$) and those who have been living with their caregiver for a shorter period ($r = -0.074$, $p = 0.047$, $n = 730$) show higher levels of reactivity. Among sociodemographic variables, male caregivers reported greater reactivity in their dogs ($r = 0.105$, $p = 0.005$, $n = 730$).

Among intrapersonal variables, higher levels of depression, anxiety, and stress in caregivers were associated with increased R/AMs ($r = 0.098$, $p = 0.008$; $r = 0.069$, $p = 0.032$ 1-tailed; $r = 0.175$, $p < 0.001$, $n = 730$, respectively). Regarding personality, caregivers with lower emotional stability — that is, with higher levels of neuroticism — perceive their dogs as more reactive ($r = -0.089$, $p = 0.016$, $n = 730$). In contrast, caregivers with a more open personality report lower levels of reactivity in their dogs ($r = -0.091$, $p = 0.014$, $n = 730$). Concerning attachment styles, caregivers with an avoidant style ($r = -0.067$, $p = 0.036$ 1-tailed, $n = 730$) and those with an anxious style ($r = 0.107$, $p = 0.004$, $n = 730$) reported greater reactivity in their dogs.

Among the interpersonal variables, caregivers with higher levels of empathy perceive their dogs as more reactive ($r = 0.078$, $p = 0.035$, $n = 730$). In the caregiver-dog relationship, it was found that caregivers who perceive more costs in the relationship evaluate their dogs as more reactive ($r = 0.252$, $p < 0.001$, $n = 730$), whereas greater caregiver-dog interaction is associated with lower reactivity ($r = -0.099$, $p = 0.007$, $n = 730$). Caregivers with more negative attitudes toward aversive training ($r = 0.219$, $p < 0.001$, $n = 730$), and those with a greater ability to perceive chronic pain in dogs ($r = -0.115$, $p < 0.001$, $n = 730$), report lower reactivity in their dogs. The data also show that caregivers who experience greater emotional comfort from their dogs' presence evaluate them as less reactive ($r = -0.138$, $p < 0.001$, $n = 730$).

Among caregiving and management variables, dogs that attend more veterinary consultations ($r = -0.073$, $p = 0.049$, $n = 730$), receive medication ($r = -0.129$, $p < 0.001$, $n = 730$), are corrected with the word "no" (as opposed to being punished, $r = -0.086$, $p = 0.020$, $n = 420$), and know four basic behaviors (compared to those who know only one, $r = -0.096$, $p = 0.009$, $n = 399$) are evaluated as less reactive.

3.2. Regression analysis

To identify the most relevant predictors among the variables studied, four multiple linear regression models were estimated using the Enter method, since no variables entered the model related to caregiving and management (Model 5). The four estimated models are significant (Table 1), and the explained variance increases as more predictors are added. Model 4 explains 16 % of the variance in reactive behavior, as reported by caregivers ($R^2 = 0.16$). In addition to statistical significance, we emphasized the variance explained as an indicator of effect size, which provides information about the practical relevance of the associations identified. While some coefficients were small, this is expected in multifactorial behavioral phenomena, where complex interactions between caregiver- and dog-related variables occur. In the first model, the dog's age explains 4 % of the variance in reactive/aggressive behavior. The second model introduces caregiver gender, which, although not as strong a predictor, also has a significant contribution. The third model includes, in addition to these two variables, caregiver stress, which proves to be an important predictor, increasing the explained variance to 7.4 %. In the fourth model, interpersonal variables are added, significantly increasing the model's predictive power to 16 %. The most important predictor is perceived caregiving costs ($\beta_{std} = .206$), followed by attitudes toward training and dog age (both with equal explanatory power), caregiver gender, stress, and the ability to perceive chronic pain. As shown in Table 1, interpersonal variables are clearly the most important in predicting reactive/aggressive behaviors (R^2 change = .087).

Next, we introduced F/A as a predictor. Using the same set of variables from this study, the predictors of F/A are the dog's age, caregiver stress, perceived caregiving costs, attitudes towards aversive training, the annual average number of veterinary consultations, knowing four basic training behaviors, and being on medication (Batista et al., submitted). The estimated model is significant and explains 40.7 % of the variability in the R/AM index, showing the strong influence these emotions have on these problems (Table 2).

4. Discussion

Starting from a broad set of variables, we aimed to identify the most important predictors of reactive/aggressive behavior. We found that the dog's age, caregiver gender and stress, perceived caregiving costs, attitudes toward aversive training, and the ability to recognize chronic pain

Table 2

Predictors of reactive/aggressive manifestations, including fear/anxiety as a predictor.

			Model 4 Including Fear/Anxiety
Gender Dummy	β_{std} (β_i)	(0.844)	0.087**
Chronic Pain Perception Scale	β_{std} (β_i)	(-0.058)	-0.082**
Fear/Anxiety	β_{std} (β_i)	(0.536)	0.622***
Intercept β_0			-0.123
Explained variance (R^2)			0.407
Model significance		F (3, 726) = 168,082 p < 0.001	

Note. ** p < .01, *** p < .001. Criterion variable = reactivity (minimum = 0; maximum = 10). Gender coded as a dummy variable: female = 0; male = 1.

in dogs were the most relevant variables, together explaining 15.8 % of the variability in reactive/aggressive behavior. Caregivers reported higher R/AMs in younger dogs, which is consistent with evidence that adolescence and early adulthood are marked by heightened excitability and less mature impulse control. These developmental factors may help explain increased reactivity in younger animals, although some studies have also reported greater aggression risks in older dogs depending on context (e.g., Casey et al., 2014). When F/A in the dog was added to the model, the explained variability increased to 40.7 %, highlighting the central role of these emotional states in this behavioral problem.

Correlation analyses revealed that younger dogs and females showed higher levels of R/AMs. Findings on sex and neuter status as risk factors for aggression are inconsistent. While some studies report higher risks in males (Mikkola et al., 2021), others highlight increased aggression in females, particularly those that are spayed (Scandurra et al., 2018; O'Neill et al., 2017). Neutering has also been linked to higher stress and aggression in some contexts (Farhooody et al., 2018; Kolkmeier et al., 2024). In our study, caregivers reported higher R/AMs in females, especially spayed females, adding to the evidence that sex- and neuter-related effects vary across populations and contexts. Dogs who had lived with their caregivers for less time also showed higher R/AMs.

Among caregiver sociodemographic variables, only gender was associated with R/AMs, with male caregivers reporting higher levels. While we did not measure interaction style directly, previous studies suggest that male owners are more likely than female owners to use

Table 1

Predictors of reactive/aggressive manifestations.

		Model 1 Dog characteristics	Model 2 Sociodemo-graphic variables	Model 3 Intrapersonal Variables	Model 4 Interpersonal variables	Model 5 Caregiving and management
Dog's age	β_{std} (β_i)	-0.197*** (-0.104)	-0.196*** (-0.104)	-0.194*** (-0.102)	-0.156*** (-0.083)	-
Gender Dummy	β_{std} (β_i)		0.104** (1.006)	0.099** (0.957)	0.128*** (1.239)	-
DASS: Stress	β_{std} (β_i)			0.169*** (0.546)	0.121*** (0.391)	-
MDORS: Perceived Costs	β_{std} (β_i)				0.206*** (0.707)	-
Attitudes Toward Aversive Training	β_{std} (β_i)				0.156*** (0.473)	-
Chronic Pain Perception Scale	β_{std} (β_i)				-0.120*** (-0.086)	-
Intercept β_0		3.102	2.143	1.178	-.794	-
Explained variance (R^2)		0.037	0.047	0.074	0.158	-
Increment (R^2_{change})		0.039***	0.011**	0.028***	0.087***	-
Model significance		F (1, 728) = 29.277, p < 0.001	F (2, 727) = 18.915, p < 0.001	F (3, 726) = 20.450, p < 0.001	F (6, 723) = 23.845, p < 0.001	-

Note. * p < 0.05, ** p < 0.01, *** p < 0.001. The criterion variable was reactivity (minimum = 0; maximum = 10). Gender was coded as a dummy variable: female = 0; male = 1.

aversive or mixed training approaches (Blackwell et al., 2012; Woodward et al., 2021). Given the established links between aversive methods and increased risks of negative affective states and problematic behaviors, this may provide a plausible explanatory pathway for the association observed. However, our sample included a small proportion of male caregivers, which calls for caution in interpreting these results and highlights the need for replication in more balanced samples. In intra-personal variables, caregiver anxiety and depression were positively associated with dog R/AMs, supporting findings by Barcelos et al. (2023a) and Clarke and Loftus (2023). Notably, this study is, to our knowledge, the first to identify an association between caregiver stress and R/AMs further emphasizing the impact of caregiver mental health on dog behavior.

Both avoidant and anxious attachment styles were positively associated with dog R/AMs. This partly aligns with Gobbo and Zupan (2020), who found that avoidance relates to aggression toward caregivers, while anxiety relates to lower aggression toward strangers. Our findings suggest that any insecure attachment style may increase reactivity/aggression manifestations, reinforcing the importance of fostering secure caregiver-dog relationships through consistent and responsive caregiving.

The positive link between caregiver neuroticism and dog reactivity aligns with Dodman et al. (2018) and Gobbo and Zupan (2020), who associated caregiver emotional instability with aggression-related behaviors. Extraversion, however, was not correlated with R/AMs in our study. This may reflect differences in measurement tools, as Gobbo and Zupan assessed dog-chasing behavior and Dodman et al. used a shortened aggression-focused version of the C-BARQ.

Overall, caregivers' psychological instability - whether linked to neuroticism, insecure attachment, or symptoms of anxiety, depression, and stress - was associated with higher levels of reactive/aggressive behavior in their dogs.

In the interpersonal domain, empathy was positively correlated with R/AMs, suggesting that more empathetic caregivers may have more reactive dogs. This supports Szánthó et al. (2017), who proposed that high empathy can increase dog reactivity through emotional contagion, biased perception, and inadvertent reinforcement. These findings suggest that while moderate empathy may be beneficial, excessive empathy without behavioral knowledge could be counterproductive.

Contrary to what is suggested in the literature, anthropomorphism was not correlated with R/AMs.

Perceived caregiving costs emerged as one of the strongest predictors of R/AMs, supporting Neessen (2013), who associated higher perceived costs with more conflict behaviors in dogs. These findings highlight the relevance of caregivers' subjective perceptions for animal welfare. Greater caregiver-dog interaction was associated with fewer R/AMs, suggesting a protective effect, while emotional closeness was not significantly related, contrary to Somppi et al. (2022). Additionally, positive attitudes toward aversive training were linked to increased R/AMs, consistent with Dodman et al. (2018). Although we did not assess the actual use of aversive methods, attitudes are recognized as strong predictors of behavior (Eagly and Chaiken, 1993), and such attitudes may therefore reflect a greater likelihood of endorsing or tolerating interactions that undermine trust and safety, contributing to reactive and aggressive behaviors.

The negative association between chronic pain perception and reactive/aggressive behaviors suggests that caregivers who can recognize chronic pain may act promptly to prevent the development of pain-related R/AMs. This finding also supports a link between chronic pain and reactive/aggressive behaviors, as proposed by Mills et al. (2020) and Morey and Grau (2013).

In line with findings on aversive training attitudes, using "no" as a corrective cue was associated with lower R/AMs than using punishment, suggesting that assertive verbal cues may set boundaries without inducing negative emotional states. In contrast, punishment may trigger F/A, reinforcing reactive behaviors. Additionally, dogs not on

medication and those who know only one basic behavior showed higher levels of R/AMs.

To determine which of these variables are truly important in explaining R/AMs, we estimated several regression models. We identified six variables as the most relevant predictors. The most important were:

- (1) perceived caregiving costs, suggesting that a greater sense of strain in the relationship increases dogs' reactivity;
- (2) attitudes toward aversive training, which were associated with more frequent reactive behaviors;
- (3) Caregivers reported increased levels of reactive behaviors in younger dogs;
- (4) caregiver gender, with dogs of male caregivers displaying higher reactivity;
- (5) caregiver stress, which remained a significant factor, reinforcing the link between the caregiver's emotional state and the dog's behavior; and
- (6) the caregiver's ability to recognize signs of chronic pain in their dog, which was associated with lower reactivity.

In our dataset, chronic pain (operationalized as osteoarthritis or other health problems) was not positively associated with R/AMs; most dogs with osteoarthritis were medicated, which may indicate that pain was effectively managed. However, caregivers' ability to recognize chronic pain signs in their dogs was associated with R/AMs. Caregivers with poorer recognition skills reported higher levels of R/AMs, suggesting that difficulties in identifying subtle discomfort may hinder timely adjustments in handling or management. This interpretation aligns with clinical literature emphasizing that under-recognition of pain can contribute to behavioral problems, although our data do not demonstrate a direct pain-R/AMs link. Therefore, caregivers who are more attuned to signs of pain in their dogs may be able to intervene earlier, manage pain more effectively, and be better prepared overall to respond to their dogs' needs, ultimately reducing R/AMs. It is also possible that these individuals are more attuned to other subtle signals, such as early indicators of stress, which may make them better prepared to manage their dogs' social interactions and provide coping strategies that reduce reactivity in challenging situations. In this sense, greater sensitivity to pain may reflect a broader awareness of canine communication and behavior, which could promote more effective education and management of their dogs. Although we did not analyze the association between pain recognition and attitudes to training in this study, this represents an important direction for future research.

The block-wise analysis also revealed that the greatest increase in explained variance occurred when interpersonal variables were added to the regression model. This highlights that, beyond intrinsic factors related to the dog, such as age, reactive behaviors are strongly linked to caregivers' perceptions and practices—namely perceived caregiving costs, attitudes toward aversive training, and the ability to recognize that the dog is suffering from chronic pain.

The final model included F/A, reinforcing the idea that these emotional states underlie many R/AMs in dogs. This relationship became evident in the substantial increase in explained variance after adding the F/A index to the regression model. The explained variance rose from 16 % to 41 %, showing that these emotions play a crucial role in understanding reactive R/AMs in this sample. However, because all measures were caregiver-reported, it is possible that caregivers of dogs displaying R/AMs interpreted these behaviors as fear-based and therefore rated higher levels of F/A, which may have contributed to the strength of the observed association. These findings support the view that F/A are not merely isolated emotional responses but underlying factors that significantly influence how dogs respond to stimuli. Therefore, interventions aimed at reducing these emotional states may have a direct impact on decreasing R/AMs and promoting animal welfare.

However, a large portion of the variability remains unexplained,

suggesting that other factors, such as genetics, early socialization, and traumatic events, may play important roles (Appleby et al., 2002; Overall, 2013; Sherman and Mills, 2008). These results highlight the need to include additional variables to improve the model and gain a deeper understanding of what influences R/AMs.

Future studies could also explore whether F/A acts as a mediating variable in the relationship between factors such as dog age, caregiver stress, perceived caregiving costs, and attitudes toward training, and R/AMs. Instead of directly influencing R/AMs, these variables may contribute to higher levels of F/A, which in turn increase the likelihood of R/AMs. Future research could also investigate these relationships using longitudinal models.

This study has some limitations that should be considered when interpreting the results. First, the cross-sectional design prevents causal inferences. Although significant associations were found between the studied variables and R/AMs, it is not possible to determine the direction of these relationships or to rule out the possibility of bidirectional effects.

Second, data were collected exclusively through caregiver self-report, which may introduce perception biases and social desirability effects. The responses may reflect subjective interpretations of the dog's behavior, influenced by the caregiver's experience, expectations, or behavioral literacy. We believe this may partly explain the generally weak correlations observed, an aspect that, although rarely addressed, can also be found in other studies within the field (e.g., Barcelos et al., 2023a; Dodman et al., 2018). Moreover, no formal definition of "aggressive behaviors" was provided to participants, which may have led to variability in how this term was interpreted, potentially influencing replicability.

In addition, the sample consisted of caregivers who voluntarily participated in an online questionnaire, which may have introduced a self-selection bias. Most participants were women and individuals with a prior interest in canine behavior, which limits the generalizability of the findings to the broader population of dog caregivers.

5. Conclusion

Starting from a broad set of caregiver-related variables, we aimed to identify those most relevant to explaining R/AMs. After controlling for dog age, we found that caregiver gender (male), caregiver stress, perceived caregiving costs, and the caregiver's limited ability to recognize chronic pain in their dog was associated with greater R/AMs intensity. We also aimed to examine whether F/A is an underlying factor for this behavioral problem. The results confirmed this. The final model, which included caregiver characteristics and dog F/A, accounted for 40 % alone of the variability in this behavioral problem.

Thus, behavioral interventions targeting R/AMs should not focus solely on the dog and its behaviors. They must also consider the dog's various fears and anxieties, as well as strategies to reduce them. Intervening in variables that influence F/A, such as ensuring frequent veterinary visits, using medication when necessary, and teaching the dog some basic training behaviors, might be effective strategies.

Additionally, the caregiver should also be taken into account, particularly their interactions with the dog. It is important to address their attitudes toward aversive training, identify strategies to reduce perceived caregiving costs, and provide information to raise awareness of subtle signs of chronic pain. Our findings also suggest that caregiver gender may play a role, with male caregivers reporting higher levels of R/AMs; however, given the small proportion of male participants in our sample, this result should be interpreted with caution and warrants further investigation. These findings support the need for integrated interventions that address both the dog's behavior and emotional state, as well as caregiver characteristics, in line with the One Health perspective.

CRedit authorship contribution statement

Catarina Lavrador: Supervision, Conceptualization. **Gonçalo da Graça-Pereira:** Supervision, Resources, Conceptualization. **Batista Maria da Conceição Espírito Santo Toscano:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used DeepL Translate to translate from Portuguese to English. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Declaration of Competing Interest

The authors declare no conflicts of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2025.106840.

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