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Evidencing the impact of human-animal interaction for those living with mental health problems

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Published in
Frontiers in Psychiatry

ISSN 1664-8714
ISBN 978-2-8325-6254-3
DOI 10.3389/978-2-8325-6254-3

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Evidencing the impact of human-animal interaction for those living with mental health problems

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Citation

Ratschen, E., Shoesmith, E., Hawkins, R. D., eds. (2025). *Evidencing the impact of human-animal interaction for those living with mental health problems*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-6254-3

Table of contents

frontiers | Frontiers in Psychiatry

TYPE Editorial
PUBLISHED 10 April 2025
DOI 10.3389/fpsyt.2025.1593660

OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 14 March 2025
ACCEPTED 28 March 2025
PUBLISHED 10 April 2025

CITATION
Shoesmith E, Hawkins RD and Ratschen E (2025) Editorial: Evidencing the impact of human-animal interaction for those living with mental health problems.
Front. Psychiatry 16:1593660.
doi: 10.3389/fpsyt.2025.1593660

Editorial: Evidencing the impact of human-animal interaction for those living with mental health problems

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KEYWORDS

human-animal interaction, mental health, wellbeing, animal-assisted services, animal-assisted interventions, companion animals, animals

Editorial on the Research Topic
Evidencing the impact of human-animal interaction for those living with mental health problems

1 Global mental health impact

Mental health conditions are projected to become the leading global contributors to morbidity and mortality by 2030 (1), with depression and anxiety being the most prevalent conditions (2). In the UK, the importance of identifying unmet needs and reducing health inequalities among people with mental health conditions feature prominently in National Health Service (NHS) plans (3) and strategies (4, 5) and efforts to improve services and outcomes for people with mental health conditions have been highlighted (6–8). Therefore, it is crucial to identify early preventative strategies, along with key risk and protective factors, social determinants, and the ongoing development and evaluation of therapeutic interventions in diverse contexts.

2 Human-animal interaction: impact, challenges and progress

The potential protective and therapeutic benefits of human-animal relationships and interactions for individuals experiencing mental health challenges (9–16) have gained increasing attention. Human-animal interaction (HAI) describes a wide spectrum of relationships and exchanges between humans and animals in a variety of contexts (17), such as in the home (e.g., companion animals, also known as untrained 'pet' animals), assistance animals, in therapeutic settings such as involvement in animal-assisted services (18, 19) or

interaction with non-domestic animal species, whether wild or captive. However, the field of HAI frequently reports mixed results (20) and robust empirical evidence remains scarce, with existing studies often limited by methodological flaws (21–25). Key issues include small sample sizes and, consequently, lack of statistical power, lack of manualised intervention protocols, and well-designed control conditions (21, 26, 27). The majority of HAI research is correlational or small-scale, with a lack of high-quality intervention research designs capable of ascertaining causal relationships (28). Beyond observing outcomes, there is also a need for research to investigate the psychological mechanisms underlying the observed benefits and challenges associated with human-animal relationships and mental health interventions (29). While advancements have been made in enhancing methodological rigour of HAI research in recent years, substantial theoretical and practical challenges persist, hindering further progress in the field (30). Failure to advance the evidence base can lead to inefficient use of limited resources and result in poor, potentially unethical, and harmful practice for all parties involved (29).

Our Research Topic "Evidencing the Impact of Human-Animal Interaction for Those Living with Mental Health Problems", delves into complex HAI and relationships, aiming to provide more robust empirical evidence and deepen our understanding of how HAI (which include companion animal ownership, service dogs, and animal-assisted services) can influence mental health and well-being.

Collectively, the 11 articles in this Research Topic advance our understanding of the multifaceted nature of human-animal relationships while also offering insights into the potential mental health benefits that these interactions may offer to populations with different mental health conditions. For example, several studies explored the role of animal-assisted services involving a range of animals, such as dogs, horses, and sheep. These studies reported on the role of animal-assisted services in reducing cortisol levels (Schuck et al.) and enhancing social behaviour (Nieforth et al.) in children diagnosed with Attention Deficit/Hyperactivity Disorder (ADHD); improving social functioning and self-regulation in autistic children (Peters et al.); fostering positive emotions, mindfulness, and self-efficacy in adults with substance use disorders (Schmid et al.), and alleviating symptoms of post-traumatic stress disorder (PTSD) in veterans (Rankins et al.). Placing these findings in a broader context, it is evident that HAI holds promise as a (complementary or adjunctive) intervention to improve health-related outcomes for those with mental health and/or neurodevelopmental conditions across a range of age groups.

In addition to research on animal-assisted interventions, this Research Topic also provides valuable insights into the impact of service dogs and companion animal ownership. For example, Rodriguez et al. reported that service dogs improved sleep behaviours in autistic children, and Hawkins et al. found that young adults reported positive impacts of their pet dogs and cats on their anxiety and depression symptoms, with the animals providing temporary relief during moments of interaction. Importantly, however, Hawkins et al. emphasised the need for caution, highlighting that companion animals may not always yield positive outcomes. While living with companion animals is often portrayed in the media as inherently beneficial for (mental) health (31), the complexities and potential challenges of these relationships are frequently overlooked. An additional important consideration is the potential for strong attachment to companion animals to serve as an indicator of mental health vulnerability. For example, Wells et al. suggested that a strong attachment to companion animals may correlate with personality traits typically associated with certain mental health conditions. This finding is consistent with previous literature, which has reported a negative relationship between strong emotional attachment to companion animals and mental health (32–36). While the positive effects of service dogs and companion animal ownership are evident in certain contexts, it is essential to acknowledge the potential risks and complexities associated with strong emotional attachments, which warrant further investigation.

Overall, the showcased studies emphasise the intricate and nuanced nature of human-animal relationships. While HAI may offer protective and therapeutic benefits in certain contexts, for example through hypothesised mechanisms involving attachment to or companionship provided by the animal (11, 12, 37), it is imperative to approach HAI research with a balanced perspective. Human-animal relationships may also present risks, particularly for certain populations with mental health conditions (38). For example, in addition to the findings reported in our Research Topic, previous studies have highlighted several potential challenges, which include the financial burden of animal ownership (39), the responsibility of ensuring that an animal's needs are met (40), the grief associated with the loss of an animal (11), and the potential distress associated with the termination of animal-assisted service sessions, particularly when participants have formed an attachment to the animal (41). These factors can have significant implications for mental health.

3 Final considerations

The Research Topic "Evidencing the Impact of Human-Animal Interaction for Those Living with Mental Health Problems" offers a comprehensive examination of the potential benefits and complexities of HAI in mental health contexts. By presenting different research methodologies and perspectives, it underscores the importance of evidence-based approaches to integrating HAI into mental health contexts. As the field continues to evolve, future research should aim to address existing gaps, explore the long-term effects of HAI, and develop standardised protocols to maximise benefits while mitigating potential risks (20, 42, 43). In summary, while HAI present promising avenues for enhancing mental well-being, a rigorous, nuanced and evidence-based approach to research and practice will be essential to fully harness their therapeutic potential.

Author contributions

ES: Writing – original draft, Conceptualization, Writing – review & editing. RH: Writing – review & editing. ER: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

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frontiers | Frontiers in Psychiatry

TYPE Brief Research Report
PUBLISHED 16 October 2023
DOI 10.3389/fpsyt.2023.1258850

OPEN ACCESS

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RECEIVED 18 July 2023
ACCEPTED 25 September 2023
PUBLISHED 16 October 2023

CITATION
Applebaum JW, McDonald SE, Porges EC, Widmeyer M, Fabelo HE, Kertes DA and Cook RL (2023) Pet ownership is associated with harmful alcohol use among a cohort of people with HIV: a brief research report. *Front. Psychiatry* 14:1258850. doi: 10.3389/fpsyt.2023.1258850

Pet ownership is associated with harmful alcohol use among a cohort of people with HIV: a brief research report

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Research suggests that people with HIV (PWH), who are at high risk for alcohol and substance use, may rely on relationships with pets for companionship and stress relief. There may be common mechanisms underlying both substance use and attachment to pets. The purpose of this brief research report was to compare alcohol and substance use behaviors between pet owners and non-owners among a cohort of PWH. Participants ($n = 735$) in a survey study of PWH in Florida were asked about their alcohol and substance use behaviors, whether they owned a pet, and their sociodemographic characteristics. We used bivariate analyses and logistic regression to examine differences in alcohol and substance use behaviors between pet owners and non-owners. Pet owners had higher mean AUDIT scores than non-owners ($M_{pet} = 5$, $M_{nopet} = 4$, $z = -3.07$, $p = 0.002$). Pet owners were more likely than non-owners to use alcohol in a harmful or hazardous way (AUDIT score ≥ 8), above and beyond sociodemographic characteristics ($OR = 1.65$, $p = 0.052$). Pet owners were more likely to have ever used most substances than non-owners, and more likely to currently use alcohol ($X^2(1) = 12.97$, $p = 0.000$), marijuana or hashish ($X^2(1) = 6.82$, $p = 0.009$), and amyl nitrate/poppers ($X^2(1) = 11.18$, $p = 0.001$). Pet owners may be more likely to use alcohol and other substances at higher rates than non-owners. Reasons for owning a pet and using substances may be similar, such as coping with stress.

KEYWORDS

pets, companion animals, people with HIV, alcohol use, substance use, HIV/AIDS, pet owners, human-animal interaction

1. Introduction

Alcohol and substance use are highly prevalent among people with HIV (PWH) and are determinants of medication adherence and secondary transmission risk (1, 2). Identifying psychosocial correlates of alcohol and substance use among PWH is of critical importance both for public health and individual prognosis (1, 3, 4). Although a majority of U.S. households have at least one pet in the home (5–7), no prior studies to our knowledge

have examined pet ownership as a potential psychosocial correlate of alcohol and substance use among PWH, despite research linking pet ownership with a variety of human health outcomes (6, 8–11). It is unclear whether pet ownership and substance use may be correlated in PWH or in what direction, owing to the complex physical, social, and economic challenges of living with HIV.

One possibility is that pet ownership may be linked with lower rates of alcohol and substance use in this population. There is some evidence that pets serve as meaningful relationships for PWH. Specifically, previous studies on pet ownership among PWH suggest that for some, pets offer companionship and a nonjudgmental source of emotional support (12–18). Moreover, caring for pets can provide a meaningful social role that promotes effective self-management of HIV via stress reduction and daily caregiving tasks (18). Thus, it is possible that pet ownership may be associated with lower alcohol and substance use among PWH by providing opportunities to engage in positive coping behaviors.

Alternatively, it is also plausible that pet ownership is associated with higher rates of alcohol and substance use among PWH. At a socioemotional level, people may engage in substance use for coping with distressing emotional states and symptoms (e.g., depression, internalized HIV stigma/self-stigma) social enhancement and intoxication (i.e., to feel good and fit in), and improvement of internal emotional and physical states (19–21). Research suggests that people seek out pet ownership for similar reasons: to foster relationships, experience companionship, and to provide stress relief and psychological benefits (22, 23). At a biological level, neuromodulators that impact responses to stressful experiences as well as social affiliative behavior such as OXTR are implicated in both alcohol misuse and interactions with companion animals. For example, OXTR rs53576 is recognized as a potential genetic locus for sensitivity to the social environment, and A-carriers at this locus have been reported to engage in more substance use among males (24, 25) and engage in more petting behavior during human-animal interaction (26). For PWH, a pet may provide social and emotional comfort, but may not fully alleviate anxiety and stress. Therefore, it is possible that motivations to manage negative affectivity and cope with stress may contribute to high degrees of overlap between pet ownership and substance use.

Pets (i.e., dogs) can also act as social lubricants (27); accordingly, pet ownership may increase opportunities for social engagement, and while reduced perceived social isolation has been associated with negative mental health outcomes (e.g., anxiety and depression), alcohol and other substances of abuse are often used in social situations and may also be impacted by this same mechanism. Finally, due to the level of responsibility required to adequately care for pets, as well as associated economic stressors (e.g., veterinary care), PWH who own pets may experience a higher level of stress than non-owners, which could contribute to higher rates of negative coping strategies such as alcohol and substance use in this population (28).

Given that pet owners are systematically different from non-pet owners with regard to several demographic and contextual characteristics (e.g., gender, race, income), it is important that research accounts for these factors when comparing health outcomes for PWH and how they may vary by pet ownership status (6, 29, 30). The purpose of this brief research report was to report comparisons in alcohol and substance use behaviors between pet owners and non-owners among a cohort of PWH while adjusting for the potential confounding effects of sociodemographic characteristics.

2. Methods

Data were from Wave 3 of the Florida Cohort, a survey of PWH in Florida, run by the Southern HIV and Alcohol Research Consortium (SHARC) in 2021–2023. Wave 2 of the Florida Cohort is described in Ibanez et al. (31) and had a similar methodology and goals to Wave 3. Participants were recruited at HIV care providers, patient registries, participant referrals, and remotely via advertising. Participants completed several survey modules, available in English, Spanish, and Haitian Creole, regarding general health, health care utilization, behavioral and social factors, alcohol and substance use, mental health, and pet ownership. Participants were compensated for each module they completed. The study was approved by the University of Florida Internal Review Board.

2.1. Measures

Alcohol use: The Alcohol Use Disorders Identification Test (AUDIT) is a validated 10-item questionnaire measuring alcohol consumption, drinking behavior, and alcohol-related problems (32). Possible scores on the AUDIT range from 0–40; based on AUDIT scoring criteria, participants who scored eight or above were coded as using alcohol in a harmful or hazardous way.

Other substances: Participants were asked if they had ever used several substances, including tobacco, marijuana, heroin, cocaine, stimulants, MDMA, opioids, hallucinogens, and amyl nitrate. Those who endorsed ever having used each substance were asked if they had used the substance in the past 12 months.

Pet ownership: Participants were asked, "do you have any pets?" Possible responses were "yes" or "no."

Sociodemographic characteristics: Participants self-reported their age, race, Hispanic ethnicity, yearly family income, educational attainment, gender, and marital or relationship status.

2.2. Analytic procedures

We present bivariate analyses (Wilcoxon signed rank tests, chi-squared tests, and *t*-tests) to compare alcohol and substance use behaviors between pet owners and non-owners. We estimate a multivariate logistic regression to isolate the association between pet ownership and harmful or hazardous alcohol use above and beyond sociodemographic characteristics. We control for characteristics with known associations to alcohol use behaviors and/or pet ownership.

Of the 735 total participants, 546 both completed the AUDIT and had complete information on all variables of interest and are thus included in the multivariate analyses. Bivariate analyses and descriptive information are included for all non-missing observations.

3. Results

3.1. Descriptive information

Among the 735 Florida Cohort participants, 43% were pet owners. Participants were aged 20–80 years; the mean age for pet owners was slightly younger ($M = 48$, SD = 12.5) than non-owners ($M = 51$,

SD = 13.6; t (733) = 2.93, p = 0.004). Race, Hispanic ethnicity, income, education, and marital status varied significantly between pet owners and non-owners. Sixty-two percent of pet owners identified their race as White, 33% Black, and 5% other races,[1] while 21% of non-owners identified as White, 70% as Black, and 9% as other races (X^2 (2)=124.46, p = 0.000). Twenty-one percent of pet owners endorsed Hispanic ethnicity, versus 12% of non-owners (X^2 (1)=12.53, p = 0.000). Among pet owners, 26% made less than $10,000 per year, 38% made $10,000-29,999, 22% made $30,000-49,999, and 14% made $50,000 and above; among non-owners, 44% made less than $10,000, 35% made $10,000-29,999, 13% made $30,000-49,999, and 8% made $50,000 and above ($X^2$ (3)=31.03, p = 0.000). Sixteen percent of pet owners reported less than a high school education, 32% reported high school or GED attainment, and 52% reported some college and above; 32% of non-owners had less than high school education, 27% had high school or GED, and 41% reported some college and above (X^2 (2)=24.76, p = 0.000). Among pet owners, 48% were single, 9% were living with a long-term partner, 16% were married, and 26% were divorced, separated, or widowed; among those who did not own pets, 56% were single, 4% were living with a long-term partner, 12% were married, and 28% were divorced, separated, or widowed (X^2 (3)=11.92, p = 0.008). Gender did not vary significantly between pet owners and non-owners: 60% of pet owners were male versus 55% of non-owners, 38% of pet owners were female, versus 43% of non-owners, and 3% of pet owners reported other genders, versus 1% of non-owners (X^2 (2)=3.87, p = 0.144).

3.2. Differences in alcohol and substance use behaviors between pet owners and non-owners

Pet owners had significantly higher AUDIT scores and were more likely to use alcohol in a hazardous or harmful manner (≥8 AUDIT score) than non-owners. Pet owners were significantly more likely to have ever used alcohol, cigarettes, marijuana or hashish, stimulants, unprescribed opioids, ecstasy or MDMA, hallucinogens, and amyl nitrate or poppers than non-owners. In the past 12 months, pet owners were more likely than non-owners to have used alcohol, marijuana or hashish, and amyl nitrate. See Table 1 for statistical information.

In the logistic regression model (LR X^2 (15)=29.44, p = 0.014), pet ownership was marginally significantly associated with harmful or hazardous alcohol use (≥8 AUDIT score) above and beyond the effects of age, race, Hispanic ethnicity, income, education, gender, and marital status (OR = 1.65, p = 0.052). Age was the only other significant variable in the model: older participants were less likely to be harmful or hazardous alcohol users than younger participants (OR = 0.98, p = 0.015). Figure 1 displays the odds ratios and confidence intervals for each variable in the model.

1 This approach was employed for analytic purposes, as small group sizes are not compatible with the methodologies used in this paper. There are limitations to grouping racial and ethnic groups; for a discussion of the issues this approach can raise see (33).

4. Discussion

In this brief research report, we described differences in alcohol and substance use behaviors between pet owners and non-owners among a cohort of PWH. We found that pet owners were more likely to be current alcohol users than non-owners, tended to score higher on a standard assessment of harmful or hazardous alcohol use, and this association remained marginally statistically significant when adjusting for the effects of sociodemographic covariates in the model. Additionally, pet owners were more likely to have ever used most substances than non-owners and more likely to be current users of marijuana or hashish, and amyl nitrate.

The higher likelihood of harmful alcohol use among pet owners (compared to non-owners) in this study, at a surface level, may be somewhat counter-intuitive in the context of previous research among this population suggesting that pets may contribute to well-being and motivate PWH to maintain healthy lifestyles (13–16, 18). However, some research among PWH and other populations has shown that pet owners with strong attachment bonds may have poorer mental health than those with weaker bonds (9, 13, 34), suggesting that reliance on a pet for emotional support could be indicative of a greater need for coping mechanisms. Additionally, this study is cross-sectional and did not account for the participants' duration of pet ownership, years living with HIV, and duration of alcohol and substance use; other research has suggested that the mental health effects of pet ownership could emerge over time (35). Future research should account for these factors.

If both pet ownership (i.e., attachment to pets) and substance and alcohol use serve similar coping roles, it may be possible to harness the human-animal bond to reduce the harmful or hazardous use of alcohol and other substances. For example, if a pet owner uses substances to relieve stress, creating interventions to strengthen the human-animal bond (e.g., engaging in activities that are mutually beneficial for both human and pet) may help to reduce substance use behaviors via pet-associated stress reduction. Importantly, broader public and community-based support for pet ownership among marginalized populations, such as PWH, is pertinent in order to relieve some of the stress of pet caregiving and thus encourage healthy coping via pet support, versus unhealthy coping with substances. Pet ownership, without broader support for the human-animal bond, may serve to create more stress and thus encourage substance use, rather than reduce it. Future research should assess whether programs to support pet ownership among PWH may encourage healthy coping and thus reduce alcohol and substance use.

Though attachment to pets was not assessed in this study, previous research suggests there are common biological, psychological, and social mechanisms underlying both heavy alcohol use and strong attachments to pets. For example, recent experiences of stress, state or trait anxiety, and adverse childhood experiences coupled with neurobiological predispositions to experience altered responses to stress and social interaction including but not limited to the oxytocinergic system may all play common roles in both substance use and attachment to pets (36). These factors, both individually and in combination, should be assessed in future research on pet ownership and alcohol and substance use, particularly among PWH and other marginalized populations.

10.3389/fpsyt.2023.1258850

TABLE 1 Pet owners versus non-owners: alcohol and substance use behaviors.

Variable	Pet	No pet	*p*-value	X^2(df)/z	*n*[a]
AUDIT score in past year (0–39)**	5 (*M*) (*SD* = 6.9)	4 (*M*) (*SD* = 6.7)	0.002	−3.07	566
Hazardous alcohol use in past year*	25%	18%	0.042	4.14 (1)	566
Ever used:					
Alcohol***	91%	81%	0.000	14.32 (1)	731
Cigarettes**	70%	60%	0.004	8.14 (1)	731
Marijuana or hashish**	75%	64%	0.001	10.30 (1)	733
Heroin (snort or smoke)	10%	11%	0.799	0.06 (1)	733
Injection drugs	14%	14%	0.931	0.01 (1)	733
Cocaine or crack	48%	43%	0.206	1.59 (1)	733
Stimulants***	28%	17%	0.000	15.07 (1)	733
Opioids (not as prescribed)***	22%	12%	0.000	14.29 (1)	733
Ecstasy/MDMA*	22%	15%	0.014	6.01 (1)	733
Hallucinogens**	23%	14%	0.001	10.96 (1)	733
Amyl nitrate/poppers***	33%	16%	0.000	30.43 (1)	733
Used in past year:					
Alcohol***	73%	60%	0.000	12.97 (1)	731
Cigarettes	37%	34%	0.363	0.83 (1)	731
Marijuana or hashish**	46%	36%	0.009	6.82 (1)	725
Heroin (snort or smoke)	1%	2%	0.368	0.81 (1)	730
Injection drugs	4%	5%	0.423	0.64 (1)	733
Cocaine or crack	9%	12%	0.177	1.82 (1)	723
Stimulants	9%	6%	0.238	1.39 (1)	729
Opioids (not as prescribed)	6%	3%	0.125	2.36 (1)	733
Ecstasy/MDMA	5%	4%	0.431	0.62 (1)	732
Hallucinogens	3%	2%	0.380	0.77 (1)	732
Amyl nitrate/poppers**	16%	8%	0.001	11.18 (1)	733

[a]Sample sizes vary due to skip logic, module design, and missing observations.
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

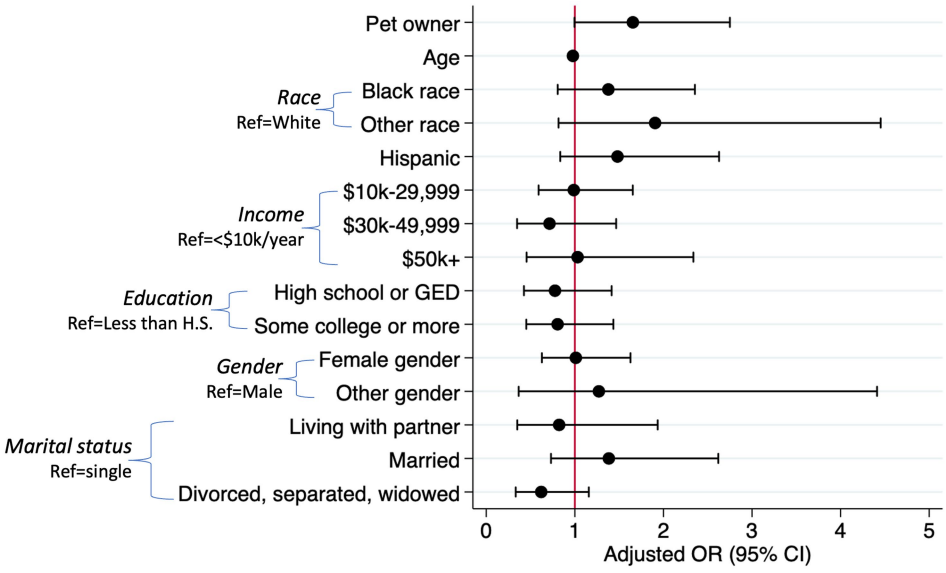

FIGURE 1
Logistic regression predicting harmful alcohol use (AUDIT score of 8+) (*n* = 546).

Data availability statement

The datasets for this article are not publicly available due to concerns regarding participant/patient anonymity. Requests to access the datasets should be directed to the corresponding author.

Author contributions

JA: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. SM: Conceptualization, Funding acquisition, Writing – original draft, Writing – review & editing. EP: Conceptualization, Writing – review & editing. MW: Data curation, Investigation, Writing – review & editing. HF: Data curation, Writing – review & editing. DK: Writing – review & editing. RC: Conceptualization, Funding acquisition, Investigation, Resources, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The Southern HIV and Alcohol Research Consortium NIH/NIAAA U24 AA022002, R01AA030481, and pilot funding from the SHARC Center for Translational HIV Research provided funding for this study.

Conflict of interest

SM was employed by Denver Zoological Foundation. MW was employed by Unconditional Love, Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 15 February 2024
DOI 10.3389/fpsyt.2024.1355317

OPEN ACCESS

EDITED BY
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RECEIVED 13 December 2023
ACCEPTED 29 January 2024
PUBLISHED 15 February 2024

CITATION
Hawkins RD, Kuo C-H and Robinson C (2024) Young adults' views on the mechanisms underpinning the impact of pets on symptoms of anxiety and depression. *Front. Psychiatry* 15:1355317. doi: 10.3389/fpsyt.2024.1355317

Young adults' views on the mechanisms underpinning the impact of pets on symptoms of anxiety and depression

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Introduction: Emerging adulthood is considered a peak age for the onset of mental health difficulties with approximately 75% of mental health disorders being diagnosed during this developmental period. Companion animals confer both risk and benefits to mental health yet the potential underpinning mechanisms which explain such impacts are not fully understood. This study aimed to gather an in-depth understanding of young adults' lived experience of how their companion dogs and cats may impact their mental health symptoms and the perceived mechanisms which explain their effects.

Methods: Semi-structured interviews were carried out with 16 young adults aged 18-26 years, from the United Kingdom, who either had a companion dog, cat, or both. All participants had difficulties with anxiety and or depression, and 12 had received a formal diagnosis of an affective disorder.

Results: Five overarching themes and one subtheme were identified through reflexive thematic analysis using an inductive approach: Theme 1: Pet impact on generalized anxiety and panic, Subtheme 1A: Pet impact on social anxiety and loneliness; Theme 2: Pet impact on low mood, depression, and stress; Theme 3: Pet impact on severe mental health and suicide prevention; Theme 4: Staying well; Theme 5: Positive outlook and successful futures. Several perceived mechanisms underpinning the impacts of pets for mental health were also identified.

Discussion: These findings have relevance for the development and evaluation of mental health interventions and treatment protocols aimed at young adults with mental health difficulties, where companion animals may prove to be effective for symptom management and improvements in positive wellbeing.

KEYWORDS

anxiety, coping, depression, human-animal interactions, pets, self-harm, suicide, wellbeing

1 Introduction

Mental health problems remain one of the main causes of overall disease burden worldwide and represent the largest single cause of disability in the United Kingdom (1, 2). There is an increased risk for psychological vulnerability in emerging adulthood, typically defined as the ages between 18 and 29 years (3, 4). Emerging adulthood spans a key developmental age where there is a transition from late adolescence into adulthood whereby societal, psychosocial, and biological factors can increase stress and cause psychological distress (5). For example, changing social roles and identities, increased risk-taking, and heightened instability are distinctive features of this period that can increase negative emotions and lower wellbeing. The availability of social support and family bonds is critical for navigating through the difficulties and uncertainties of this life stage (6, 7). Statistics have shown that the 12-month prevalence of any psychiatric disorder, particularly anxiety and mood disorders, is more than 40% in people aged 18–29 years (8) and that approximately 75% of mental health disorders are diagnosed by the end of this developmental period (9). The problems that emerge in young adulthood can persist long-term over the life course (3), yet there tends to be low help-seeking within this age group (10), and many young adults within the UK do not have access to appropriate mental health support (11). Moreover, suicide is a leading cause of death for young people under the age of 35 years in the UK (12), so identifying preventative and protective factors for young people's mental health is a key public health concern.

The preventive effects of companion animals, hereby referred to as "pets", for mental health difficulties have been a topic of interest in recent years, within both the public media and scientific investigation. With the rise of "pet therapy" (animals being utilized in therapeutic work usually involving interaction between an individual, pet handler, certified animal, and healthcare professional; e.g., 13) and the Mental Health Foundation, a UK-based charity, now recommending pets as a source of improving mental health (14), it is important to disentangle the impacts of pets for psychological health. Quantitative studies have yielded mixed and inconclusive findings, and longer-term impacts of pets remain unclear due to the reliance on cross-sectional and correlational designs, as well as variability in measures meaning difficulties with comparison and replication (15–17). Existing studies have also been critiqued for overlooking the complexity and individualities of each human–pet relationship through attempts to identify a relationship between pet ownership and decreased mental health symptoms (e.g., 18, 19), whereas the same pet could both exacerbate and reduce mental health symptoms depending on the context and type of interaction (20). It may be the case that pets help to manage mental health symptoms, offering a temporary sense of relief and preventing the worsening of symptoms, rather than eliminating them. Few studies have investigated the impact of pets on those with clinical levels of mental health difficulties, and even fewer have investigated the impact of pets on mental health within emerging adulthood when relationships with pets can offer a stable source of comfort and support in times of uncertainty and instability.

Young adults facing adversity place high importance on their pet relationships and view them as key mental health supports, helping to manage mental health symptoms and enabling them to effectively deal with major life stress (21). In the same study, young adults reported that their pets promoted positive self-image and boosted their confidence. Increased positive self-regard and related wellbeing factors were also found for pet-owning marginalized (e.g., LGBT+) emerging adults in the USA who are at increased risk for vulnerability due to adversity, discrimination, and social disparities (22, 23). Another study found that pets were featured within young adults' discourse of wellbeing, with the value being placed on meaningful interactions with pets (24). For emerging adults within the USA, dealing with hardship and avoidance of loneliness were key motivations for pet ownership (25), and research supports the impacts of pets on reduced loneliness and social anxiety within emerging adulthood (26). Although emerging adulthood is a period of increased independence, exploration, and freedom, pets can offer an important sense of autonomy, responsibility, structure, and stability, all of which are important contributors to emotional health (27). It is important to note here that negative impacts of pets on mental health have also been identified. For example, in research with adults, pets were reported to exacerbate mental health difficulties including increased maladaptive guilt, stress, worry, and caregiver burden (20); such rumination and worry can increase the risk for affective disorders (28). Furthermore, many adult pet owners report housing and financial concerns, which could be exacerbated in emerging adulthood due to a lack of stability and financial security in this life period (27). Both potential risks and benefits of pets for mental health should, therefore, be considered.

Given the increased vulnerability to mental health difficulties within emerging adulthood and the proposed preventative effects of pets for mental health symptoms, the psychological implications of human–pet interactions may be particularly pertinent during this developmental stage. However, as mentioned, few studies have explicitly investigated the impact of pets on the mental health of young adults with anxiety and depression, and emerging adults within the UK remain an underrepresented population within this field of work. Quantitative research does not allow for the exploration of the nuances of human–pet relationships, such as individual pet effects (and pet type) and the mechanisms that explain both the benefits and risks of pets for mental health. Qualitative lived experience research offers the opportunity to explore such mechanisms within this developmental period, thus understanding the why and how behind the impact of pets on mental health. The current study, therefore, aimed to gather an in-depth understanding of young adults' lived experience of how their companion dogs and cats may alleviate or exacerbate their mental health symptoms. This project focuses on affective disorders (anxiety and depression), the most prevalent mental health difficulties in this population (9). Dogs and cats were chosen because they are the most common pet types within the UK and are most often talked about in relation to mental health (20, 29).

2 Materials and method

2.1 Design and participants

A qualitative approach was undertaken whereby in-depth semi-structured interviews were carried out online. Inclusion criteria included the following: 1) aged 18–29 years; 2) had a pet dog, cat, or both; 3) lived in the United Kingdom; 4) fluent in the English language; and 5) struggling with anxiety and/or depression/low mood. A clinical mental health diagnosis was not a requirement for participation due to low help-seeking within this population (10).

Our sample (N = 16) included 14 individuals who self-identified as female and two participants who self-identified as non-binary. The age range was 18–26 years (M = 22). Most participants (n = 11) identified as heterosexual, five identified as LGBTQ+, and one answered "other". Most participants lived in England (n = 14), one participant lived in Scotland, and one lived in Ireland. Most participants were in a romantic relationship (n = 11) and living with their caregivers (n = 7). Six participants had a pet cat, six participants had a pet dog, and four participants mentioned having both. Most participants (n = 12) lived with their pets at the time of the study, and most (n = 13) did not have any other types of pets. Length of pet ownership ranged from 5 months to 10 years. Four participants mentioned that their motivation to acquire their pet was for their mental health. Full participant details can be found in Table 1.

Despite the previously reported low help-seeking in our population, 12 participants in our sample had received a clinical diagnosis for anxiety, depression, or both, and 13 participants reported having sought help for their mental health, predominantly counselling, therapy (e.g., cognitive behavior therapy), or medication. Some participants mentioned previously having suicidal thoughts or having been hospitalized due to their mental health. Additional diagnoses, co-diagnoses, and difficulties had also been identified including personality disorders, eating disorders, attention deficit disorder, obsessive-compulsive disorder, psychosis, and paranoia (see Table 1). Three participants were autistic, and one other participant reported being neurodivergent.

2.2 Procedure

Purposive and convenience sampling was used whereby participants were recruited *via* an advert on the UK MQ Mental Health research platform (n = 6) or through an advert on social media channels including Twitter and Facebook (n = 10). Recruitment ended when the target sample size (n = 16) was achieved. This sample size was deemed adequate for achieving theoretical saturation in qualitative designs (30). Interested participants were able to scan a QR code or access a web link to an online sign-up survey. The sign-up survey provided detailed information regarding the study and its procedure so that participants were able to provide full consent. Once participants had read the information sheet, they were directed to the next page, which was an online consent form. Participants who provided consent were then taken to a short demographic survey. Following this, participants completed an online form to indicate their time preference for the interview and were informed that they would be contacted by the researcher if they met the inclusion criteria.

All interviews were 1:1 with a single experienced researcher and took place online (Microsoft Teams, n = 15) or by telephone (n = 1). At the beginning of the interview, participants were reminded of their rights and the study's aims and purpose and were able to ask questions about the study. Given the sensitive nature of the topic, a document containing a list of mental health resources was provided by email along with health and behavior support resources for pets. An emergency contact for the interviewee was also requested prior to the interview commencing, and the researcher monitored the participant's mental health throughout the interview. If participants had both dogs and cats as pets, they were able to talk about both within the interview but were asked to make it clear which individual pet they were referring to in their answers. The interviews were audio recorded for transcription purposes. The interviews lasted between 16 and 37 minutes, with an average length of 23 minutes. At the end of the interview, participants were again able to ask any questions regarding the study before being emailed a de-brief form that thanked them for their participation and provided them with more information regarding the study with some additional relevant resources. Participants were also sent a £20 shopping voucher as a thank-you for taking part.

Demographic questions included the following: age, gender identity, ethnicity, sexual orientation, relationship status, type of accommodation (e.g., homeowner and student accommodation), and presence of children. Participants were then asked the following questions about their mental health: 1) Have you been struggling with anxiety, depression, or both? 2) Have you ever had a formal mental health diagnosis? 3) Have you ever sought professional help for your mental health? 4) Do you experience any other mental health difficulties? Participants were able to provide further details if they wished. Participants were then asked several questions about their pet including: 1) type of pet (whether a cat or dog or both); 2) number of cats/dogs; 3) whether currently living with their pet; and 4) number and type of any other pets owned. Interview questions were built around the human–pet relationship, e.g., "What does having a pet mean to you?", and pet impact on mental health, e.g., "Do you think your dog/cat has had an impact on your overall health and wellbeing?", "Do you think your dog/cat has had any impact on your feelings of anxiety (if relevant)?", and "Do you think your dog/cat has had any impact on your mood or depression (if relevant)?". Prompts for each question were used, e.g., "If yes/no, in what ways? Has your dog/cat helped with specific symptoms?"

2.3 Data analysis

Reflexive thematic analysis (TA) was used to analyse the data. TA involves a six-step coding process that includes disassembling and reassembling data and searching for patterns and meaning within the data, with the overall goal of finding overarching themes and subthemes. Although the interview questions asked about the

TABLE 1 Participant demographics.

ID	Pseudonym	Age	Gender	Mental health diagnosis	Pet	Identified difficulties and other relevant diagnoses	Ethnicity	Sexual orientation	Romantic relationship	Accommodation	Living with pet
001	Brynn	23	NB	Y	Dog	Anxiety/social anxiety, depression. Autistic.	Asian/Asian British (Chinese)	Bisexual	Y 5+ years	Homeowner (living alone)	Y
002	Lola	18	F	N	Both	Anxiety/social anxiety, depression.	White*	Heterosexual	Y 3 years	With parents/caregivers	Y
003	Avery	25	F	Y	Dog	Anxiety, hospitalized for mental health. EUPD.	White	Heterosexual	N	With parents/caregivers	Y
004	Isla	20	F	Y	Cat	Anxiety, OCD, previous suicidal thoughts, and depression.	White	Heterosexual	N	With parents/caregivers	Y
005	Ava	25	F	Y	Cat	Anxiety/social anxiety, panic attacks, depression. Suspected BPD, EUPD.	White	Heterosexual	Y 3 months	Shared housing	N
006	Leith	22	F	Y	Both	Anxiety, depression, psychosis (hallucinations), depersonalization, suicide attempts, hospitalized for mental health. BPD.	White	Heterosexual	Y 3 years	With parents/caregivers	Y
007	Osla	19	F	N	Both	Anxiety, trembling, low mood.	White	Heterosexual	Y 18 months	With parents/caregivers	N
008	Rhona	26	F	Y	Both	Anxiety, depression, panic attacks, low mood, and suicidal thoughts in past.	White	Bisexual	Y 2.5 years	Private rented place (cohabiting)	Y
009	Blair	21	F	Y	Dog	Anxiety, panic attacks, depression, low mood, hospitalized for mental health. Autistic.	White	Gay or lesbian	N	With parents/caregivers	Y
010	Skye	25	F	Y	Dog	Anxiety. ADHD. Autistic.	White	Heterosexual	Y 6 years	Homeowner (cohabiting)	Y
011	Aria	25	F	N	Cat	Anxiety/social anxiety, depression, low mood, paranoid thoughts.	Asian/Asian British (Chinese)	Heterosexual	Y 7 years	Private rented place (cohabiting)	Y
012	Edina	24	F	N	Dog	Social anxiety, sadness, thoughts of self-harm. Neurodiverse.	Asian/Asian British (Indian)	Heterosexual	Y 6 months	Shared housing	Y
013	Daisy	19	F	Y	Cat	Anxiety, panic attacks, and depression.	White	Bisexual	N	Student accommodation	N
014	Shona	21	F	Y	Dog	Anxiety, depression, hospitalized for mental health, eating disorder.	Mixed/Multiple ethnic group**	Heterosexual	N	Shared housing	N

(Continued)

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TABLE 1 Continued

ID	Pseudonym	Age	Gender	Mental health diagnosis	Pet	Identified difficulties and other relevant diagnoses	Ethnicity	Sexual orientation	Romantic relationship	Accommodation	Living with pet
015	Erwina	25	F	Y	Cat	Anxiety, panic attacks, low mood, depression. Specific phobia about feeling sick and being sick.	White	Bisexual	Y 5 years	With parents/caregivers	Y
016	Harper	19	NB	Y	Cat	Anxiety, mood swings.	White	Other	N	Student accommodation	Y

NB, non-binary; OCD, obsessive-compulsive disorder; BPD, borderline personality disorder; EUPD, emotionally unstable personality disorder; ADHD, attention-deficit hyperactivity disorder.
*Scottish/English/Welsh/Northern Irish/British.
**Any other mixed/multiple ethnic background. Note that private rented place (cohabiting) meant living with a romantic partner.

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impact of pets on mental health specifically, the questions were kept broad, and a flexible, inductive, and data-driven approach was undertaken (31, 32). A collaborative approach was undertaken whereby all researchers were involved in the coding process and agreed on the final themes. Our sample size was deemed more than sufficient for this type of data analysis (33, p. 50).

3 Results

Five overarching themes and one subtheme were identified through reflexive TA: Theme 1: Pet impact on generalized anxiety and panic, Subtheme 1A: Pet impact on social anxiety and loneliness, Theme 2: Pet impact on low mood, depression, and stress, Theme 3: Pet impact on severe mental health and suicide prevention, Theme 4: Staying well, and Subtheme 5: Positive outlook and successful futures. Several mechanisms underpinning the benefits of pets for mental health were identified through data analysis, and these are presented in Table 2. Real names have been replaced with pseudonyms throughout the results.

3.1 Theme 1: Pet impact on generalized anxiety and panic

For generalized anxiety problems (symptoms reported by most young adults in this study), pets reduced symptoms by helping to promote a sense of mindfulness, allowing young people to focus on the present moment, thus acting as a distraction away from worries. This is described by Rhona:

> "*They're just so in the moment and you know they're not thinking about life worries. They're just thinking about what's happening then and I think you can learn a lot from animals to just kind of appreciate the moment*" (Rhona).

A pet's ability to modify attention away from rumination and negative thinking patterns was also described by Skye, who had difficulties with intrusive paranoid thoughts:

> "*I have a lot of paranoid thoughts about people. Like all the time, and having my cats around, serves as a distraction, because she's always doing something interesting and then I'll be distracted and look at her and like, try to take photos of her*" (Skye).

A commonly perceived benefit of pets was the reduction of physiological symptoms of anxiety such as trembling hands, as well as the de-escalation of panic attacks. The mechanisms underpinning these effects appeared to be physical touch and petting, feelings of comfort, proximity, and the regulation of breathing, as described by participants Rhona, Ava, and Blair:

TABLE 2 Identified mechanisms underpinning the benefits of pets for anxiety and depression.

Mechanisms underpinning benefits of pets for mental health		
Pet behavior: proximity seeking, eye contact, "watching" or "checking" behavior, attentiveness, and responsiveness, attuned to emotions, physically affectionate, sleeping in proximity, sounds (e.g., purring)	Human–pet behavior: physical touch/petting, observing pet, taking photos, looking at photos of pet, talking to/confiding in pet, including pets in social interactions and activities, talking about pet to others, eating at set mealtimes with pet, shared activities, and quality time together	Pet perceived as consistent, readily available, as enjoying time spent with owner, perceived learning from them
Increased mindfulness, focus on the present moment	Increased sense of safety, protection, and reassurance, reduction/prevention of harmful thoughts	Company and comfort without judgement, expectations, or pressure. No opinions or negative feelings towards owner
Distraction, modify attention away from worries, rumination, and paranoid thoughts	Identification with pets and sense of mutual support	Increased joy and pleasure, comic relief, and sense of fun
Increased relaxation and sense of calm	Social catalyst/facilitating social interactions	Feeling valued and appreciated
Feeling loved or "chosen"	Help with disengaging from social interactions	Increased sense of purpose. Feeling needed and/or relied on for care
Better emotion regulation	Increased energy and encouragement to engage in healthy activities	Increased company/ companionship
Increased physical exercise and time spent in nature	Increased motivation/will to live	Reminder to "keep tabs" on own mental health and to engage in self-care
Increased sense of responsibility and caregiving role	Increased sense of routine and structure	Increased self-control, sense of independence
Feeling productive, a sense of achievement and self-pride	Increased resilience and ability to cope with stress, adversity, and severe trauma, and stress relief	Sense of emotional support
Motivation to seek mental health treatment and to avoid re-admission to hospital	Increased optimism, hope, and positive outlook	Motivation to continue/ pursue work and/ or education

> "*That feeling of comfort can just kind of reduce the feeling of panic you know, the anxiety might still be there very much mentally and physically, but it can reduce it, can stop it getting worse to a certain extent, if that makes sense, because, you know, you're not necessarily alone. You have another wee creature there that's with you and loves you*" (Rhona).
> "*I've had a few, like panic attacks. It definitely helps sort of calm me down in those situations, like giving them a stroke or something has quite helped me sort of get a hold of my breathing and stuff*" (Ava).
> "*When I had problems about like going to school and going to college, feeling really anxious about those and having panic attacks, I think they, you know, it's something straight away that could calm you down, especially when you're in that high kind of emotional state when you're really panicked*" (Blair).

The word "*calming*" in reference to pets was commonly reported, with physical affection and touch being important mechanisms, which underpinned this effect, along with the pets' emotional and behavioral state being reflected onto themselves:

> "*If they're calm around me, then there's nothing to sort of be anxious about. So, when they're calm, it sort of reflects on to me*" (Lola).

Ava described how having her cat sleeping and purring next to her, as well as petting her cat, helped her to feel relaxed and lowered her anxiety. Pets were, therefore, perceived to have the ability to help regulate negative emotions when in a highly aroused state; this not only alleviated anxious feelings but also helped to increase positive mood and stabilize mood swings:

> "*I deal a lot with like mood swings, so erm, he helps me feel a lot more stable. Just having like a stable source of comfort in a way*" (Harper).

This ability to regulate mood was particularly important for one participant who was going through treatment for suspected borderline personality disorder, helping to keep their mood "***steady and stabilized***". For specific anxiety problems, pets reduce symptoms by increasing a sense of safety. For example, Avery described how her dog helped her to feel safe when home alone, and Lola described how her cat helped with her fear of the dark:

> "*I feel like when he is by my side or with me in the same house, I feel a lot less scared I suppose. I am scared without him*" (Avery).
> "*I've always had a fear of the dark from some childhood problems, and she'd always come in and she would always sleep behind me. So, I knew I was never alone when it came to the nighttime*" (Lola).

Interestingly, identifying with a pet that was also perceived to be anxious helped to promote the human–pet bond and provided a sense of mutual support and anxiety relief:

> "*I think it kind of helps in a way that that she can be quite an anxious dog. So it's kinda like I'm there for her and she's also there for me. A bit of a mutual support going on. I'm kind of her emotional support human*" (Brynn).
> "*I think we're both anxious in regard to not wanting to be on our own and I think being together helps us feel less alone kind of thing*" (Avery).

3.2 Subtheme 1A: Pet impact on social anxiety and loneliness

Social anxiety was a common problem reported, and pets were perceived to be beneficial in two key ways. The first was during social interactions, acting as a social catalyst, increasing social connections, or politely disengaging from social interaction when feeling overwhelmed. The second mechanism was through providing company when socially withdrawing or when feeling lonely or alone. A pet's ability to be an important "ice breaker" and "social catalyst" was described by Ava and Brynn:

> "*Everyone likes talking about their own pets, so like it definitely is like an icebreaker in social situations*" (Ava).
> "*She's a small, cute dog. Everyone's like, aww, can I say hi to the dog. So I think there's like a somewhat of a social element as well*" (Brynn).

These social benefits were mostly reported by dog-owning participants; this was because dog owners were able to engage in more social interactions that involved their animals outside of their home, for example, including them in social activities, such as meeting their friends in dog-friendly pubs. When social interactions became overwhelming, pets were a good way to "*disengage*", and this was particularly important for neurodiverse young people, as described by Brynn:

> "*When I'm feeling stressed in a social situation, she very much helps with the kind of almost like a way out. You know, a way of kind of being able to politely disengage and then kind of take a moment to like, regulate*" (Brynn).

Pets also provided non-judgemental company including physical affection "*without pressure*" of verbal communication and without expectations from the social interaction:

> "*Social interactions can be a bit much when you're feeling low, it's not too much when you have an animal because there's no*

> *expectation there … you don't have to talk to them, they don't have to talk back*" (Rhona).
> "*Sometimes you know if you have a person next to you when you're feeling anxious or panicky or whatever they might be trying to speak to you or do something. Sometimes it can make it worse, but with an animal you know, they're never gonna speak to you or kind of bug you or whatever. They're just chilling there, and especially coz cats are so, like chill*" (Erwina).
> "*Having a pet is like having a friend at home like where he/she wouldn't really like have opinions or like urgh negative feelings towards me. And I don't need to overthink if my cat likes me or not like, like it urgh, different from me interacting with people*" (Aria).

Having "*someone there*" or being "*not alone*" was important, especially when socially withdrawing from others, during relationship breakdowns, when "*feeling down*" or "*feeling low*", or when feeling isolated and experiencing loneliness. Harper talked about living alone and how their pet provided important company and support, especially when they were not feeling well. Consistency, feeling that their pet was readily available, along with the pet being non-judgemental, was also important for many young people:

> "*I struggle with like friendships and feeling lonely. So like when she wants to do things with me, it just makes me feel like less alone. She's just always there and she doesn't judge me*" (Isla).
> "*I think a big part of having mental illness is like loneliness and not having anybody around and sometimes, you know, you just feel so isolated. So it's nice to, even if you don't get out and see people you know, like you're too ill or unwell or whatever, you still have your pet in the house with you. They're still around like, they're always there*" (Erwina).

Lola talked about being an only child and how her cats provided company especially when her mum was unavailable or when she felt that she could not confide in her mum during difficult times:

> "*Whenever I feel alone or like, I just can't talk to my mom about things, I'll just go and spend more time with them*" (Lola).

Edina, talked about her dog being an important source of affection and company following negative social interactions such as arguments or fights with friends or family members. Edina also alluded to the ability of her dog to "check" on her following these negative interactions, seemingly being attuned to her emotions:

> "*I usually end up going to my room [after an argument] and then I'll usually leave the door open, like a little bit, because sometimes [dog] will walk in and she'll just sit on the bed and like, you know, watch TV with me. And it's just like, you know, instantly, I just feel better. There's like another person in the room with me who like isn't gonna say anything. I know she understands that. You know that what happened like was like a little difficult for me. So she just came to see. It's like coming to check on me*" (Edina).

The perceived ability of pets to be attuned and responsive to a young person's emotions, and their "checking behavior", was also seemingly important for regulating and improving mood and thus reducing symptoms of depression, as reported in Theme 2.

3.3 Theme 2: Pet impact on low mood, depression, and stress

Most young adults reported having difficulties with low mood or "*feeling down*", and some mentioned having difficulties specifically with depression. In relation to their pets, these participants used words such as "*cheer up*", "*dopamine boost*", "*mood booster*", or "*mood lifter*". One way through which pets improved mood was through laughter and comic relief, with young people reporting that their pets were "*cute*" and did "*silly things*" to make them laugh. Overall, pets increased feelings of joy and a sense of pleasure:

> "*We're there just having a good time and it just really makes me feel like happy and just makes you look at life in a really nice way, just sort of like that I'm just happy with everything and it changes my whole mood, definitely*" (Osla).
> "*Every time I saw them, it was like, I felt like ten times better. And I was like, OK, so life is fine. Like, you know, I'm all fine. Everything will be OK and yeah*" (Edina).

Edina continued to describe how even just looking at pictures of their dog when apart helped to lift her mood on difficult days. Pets enable young people to feel valued and appreciated, through the perception that the pet enjoys spending time with them:

> "*I think it makes me feel more like I'm valued and like someone appreciates me being there … It makes me feel really happy because it makes me feel like he wants to be around me*" (Harper).

Pets, therefore, helped young people to "*feel better*" and seemingly provided a more positive outlook on life in general, even without daily physical contact. Important mechanisms through which pets improved low mood were through providing company, as well as being attentive, responsive, and physically affectionate:

> "*I mean the feeling depressed and sad as well I think coz again, it's just that company like I might just be sitting on my bed feeling like crap or whatever and urm. He's just around. He's there. It's nice to have, like, another living thing around with you*" (Avery).

> "*She has this way of being incredibly persistent in trying to cheer you up. It's very difficult to continue crying and being upset when a dog with an almost sandpaper tongue won't stop licking your face. So that, I mean, certainly you know, it's highly effective*" (Bryn).

For low mood and depression, an important reported benefit of pets was an increased sense of purpose. Young people reported that their pets helped them to "*get up*" and "*out of bed*" and to engage in healthy activities such as going for a walk outside:

> "*You know, some days I wouldn't be able to even get out of bed and you know I couldn't do anything. Now I get up every day for him. You know, I get up every day. I want to get up for him and take him outside and you know go for walks and play with him. You know it's really really made an impact*" (Leith).

This sense of purpose was facilitated through a sense of responsibility and caretaking role within the pet's life and feeling "*needed*":

> "*Before, I sort of feel like I didn't really have much of a purpose, I suppose, but I think him showing that, you know he loves me, and he needs me. And you know that has got such a positive impact on me that you know I need to get up every day for him you know*" (Leith).

For Rhona, this sense of purpose was important following a traumatic event in her life, which left her struggling with her mental health:

> "*About five years ago, I did have quite a traumatic event that happened in my life and just everything changed. I was taken out of university and stuff like that, and I was at home and that's when I got the dog, and she just give me such a purpose. It's always give me a sense of purpose and if my mental health was ever at a very low point, I could look at them and remember that I'm there for them*" (Rhona).

This sense of purpose helped young people to stay well, which is expanded upon in Theme 4, as well as being important for suicide and self-harm prevention as described in Theme 3.

3.4 Theme 3: Pet impact on severe mental health and suicide prevention

Most young adults reported severe mental health difficulties, with mentions of previous self-harm and being hospitalized due to suicide attempts. Additional diagnoses were also reported including eating disorders, psychosis, obsessive-compulsive disorder, and specific phobias (as reported under the subtheme for anxiety). For these participants, additional benefits of pets were reported that are worth mentioning here. For example, Shona described how eating at set mealtimes with her dog was helpful:

> "*I've struggled with an eating disorder. It's silly in a way to think about. But like the fact that he [dog] will eat at set times, I'd just sit and eat with him. So, I guess in that way like it was nice to just have the company*" (Shona).

One participant, Leith, who experienced psychosis, mentioned that although she still hallucinated, she felt that these hallucinations had reduced since having her pet dog. Leith described how her dog was responsive and seemed to sense when she was having symptoms; her dog sought physical affection and proximity, which helped to reduce symptoms:

> "*I used to get like a lot of hallucinations and things which obviously would give me a lot of anxiety. I think of like situations in my head that make me anxious and things. And you know, I think he [dog] can, he can sense it, you know, because once I get into that sense he comes and sits on me or sits next to me and just lays his head on me and sitting there just stroking him. It all, it all just goes away, you know? And it's crazy to think that an animal can do that really, he really, really can*" (Leith).

Pets were also talked about in relation to suicide prevention, being an important "*protective factor*" and helping to prevent "*dark thoughts*", with strong beliefs about a pet's ability to prevent harmful thoughts and acts of future suicide attempts:

> "*I used to get really dark thoughts, and in 2021, you know I had quite a major suicide attempt. I was in hospital for quite a long time, and again I've noticed since that, I've had the dog, I haven't thought that way at all. I was only thinking this the other day I was like I don't remember the last time I felt that way and it genuinely has been since I've got my dog*" (Leith).

One participant, Shona, spoke about her dog being helpful once discharged from an inpatient unit, helping her to keep safe, especially during periods of solitude such as when her mum was away:

> "*…But because my dog was there like, he helped keep me safe in a way. So I had something to do, like to look after, and it gave me sort of like a focus and the motivation to keep on like*" (Shona).

Along with this sense of focus and motivation, participants reported that pets prevented thoughts and acts of suicide through a sense of connectedness and bond to the animal and not wanting to "*leave*" them. Pets also provided a sense of "*hope*" and a "*reason to live*" through feeling needed and responsible for their pets' care:

> "*I do remember feeling quite suicidal at one point and looking at her and being like I can't leave her. And she was such a protective factor for me. In that time she was just such a wee ray of sunshine that I didn't have anywhere else in my life at that time*" (Rhona).
> "*He [dog] would come and visit with my parents when I'd be allowed outside the ward or whatever. And I think that helped mental health, cause it was kind of like something to keep hopeful for. And you know, when I was at my lowest and thinking about things, it was something that was like oh, you know like a reason to live and stuff I guess*" (Blair).
> "*But like they're a responsibility. So like when I was depressed like, I would have suicidal thoughts and like, it would go through my mind that like, but I need to take care of them*" (Isla).

Beliefs surrounding a pet's ability to understand and respond to human feelings were also reported upon in relation to suicide prevention. For example, one participant, Edina, had strong beliefs surrounding her dog's ability to pick up on her thoughts of self-harm, seeking proximity and eye contact with her in a perceived attempt to prevent her from harm, as well as feeling as if there was someone "*watching*" and protecting her:

> "*…I feel like they somehow knew [they were having harmful thoughts], but they will just come up and like, check on me and like they just come and sit with me, sometimes they would both sleep on my bed. It was almost as if, like, there was like another person in my room … sometimes they're, like, just glared at me when I was talking something really stupid … Like there's been days when I have been really sad, I've had like thoughts of self-harm. Sometimes I've had thoughts and like you know, the dogs have been around, and it was sort of like another person who's watching me have these thoughts and I just. I just felt like 'ohh what am I doing' like you know or like, you know things are hard and they will get better*" (Edina).

It is important to note that for one participant, Blair, losing her family pet that she was strongly attached to increased harmful thoughts of suicide, and this was her first experience of bereavement:

> "*Losing him was I guess very impactful for me. And I guess the, you know, the suicidality and the thoughts and things like that, that was very strong at that time because attachment was lost*" (Blair).

3.5 Theme 4: Staying well

This theme describes young adults' beliefs about the ability of their pets to help them "*stay mentally healthy*" through "*keeping tabs*" on their mental health and to foster increased self-control and motivation to engage in activities or behaviors that will maintain positive wellbeing and reduce negative symptoms. Part of this was their pet's reliance on them for their care and needs to be met:

> "*You kind of have to, have that like control over yourself when something is relying on you. Quite a protective factor in terms of keeping somewhat at least keeping tabs on my own health. You're kind of always reminded like, you know, I have to kind of stay well, I guess*" (Brynn).
> "*The fact that like, he needs things, and like he needed me. Urm he got me out of bed, like I take him for a walk, I have things I need to do for him*" (Shona).

A common reflection was that pets helped to improve wellbeing and were a motivator to "*keep well*" by providing routine and structure. Through caring responsibilities, pets helped to increase a sense of independence, especially when living alone, which in turn increased wellbeing through increased motivation to look after themselves. A sense of purpose, feeling productive, self-pride, and a sense of achievement were also commonly referred to by pets in helping to keep mentally healthy:

> "*It gives me that sort of sense of like purpose, you know? Like if I wasn't here, you know, I feel like they would be upset and I, you know, I don't want, don't want that for them*" (Leith).
> "*I was really sick and just like, really depressed, and I barely went to school. When I got him, because I was at home like all the time, it was suddenly just like this, this living thing that I could take care of. It was something that almost, you know, like felt productive. It was like an achievement, you know*" (Erwina).

Part of keeping well was increased motivation and encouragement to "*get up and do things*", to go outside for a walk or to play, increasing overall energy and time spent in nature and engagement in physical activity. Therefore, this mechanism was mostly relevant to dog owners:

> "*I know that going outside objectively is good for me, but oh God, do I not want to do that? That's like the last thing I want to do … so I think having a dog in that sense like definitely it means that I'm doing that on a regular basis*" (Brynn).
> "*…and I've sort of been inside all day, like feeling like a bit like unmotivated and then the dog was sort of like, want to go out for walks and stuff. It helps me to get outside and do things as well and that also improves my mental health*" (Osla).
> "*…that's [dog walking] the most physical activity that I get sometimes. So it's really helpful with, like when I have like severe anxiety, going out and getting that fresh air really helps*" (Edina).

It is worth noting here that young people were asked a question in the interview regarding potential pet impact on healthcare decisions relating to mental health, but most young adults reported no impact. However, quite a few participants had received medical treatment for their mental health, and pets were

reported to have increased their motivation to stay well and avoid going back to the hospital or increased their motivation to seek mental health treatment:

> "*I've been in hospital with my mental health five times. Erm, and he's [dog] been (one of my reasons) to get like, get well and get out of hospital kind of thing*" (Avery).
> "*I remember thinking I need to get myself sorted … I did probably seek therapy if I was, you know, looking at my dog and thinking that she was only reason I was there*" (Rhona).
> "*I was in hospital for a little while, partly due to my mental health. I was there for a bit. I think part of erm, sort of wanting to get me home was my cat. Erm well, the home environments' generally better obviously. But like I think part of sort of wanting to get home to my cat and stuff and it being more helpful to have them*" (Daisy).

One participant spoke about how having her cat present and near to her during online counselling sessions improved the sessions through decreasing anxiety and increased reassurance and sense of safety:

> "*I've seen a few different counsellors with regards to my depression and my anxiety, but I thought I'd never really got anywhere with them. A few of the meetings I had with them was during Covid when I was at home, and I felt when I talked to them, I sometimes will get anxious in myself. So when I spoke to them at home having like I said, one of my cats next to me just gives me that reassuring feeling that I am at home. I am with my cats in a safe place*" (Lola).

3.6 Subtheme 5: Positive outlook and successful futures

This theme encapsulated beliefs about pets having a positive life impact through increasing resilience and ability to cope with daily stressors as well as adversity and stressful life periods. Pets also increased optimism and enabled a more positive outlook on life, increasing chances of successful futures. Many young adults talked about how their pets helped them to cope with university stress, especially around exam times and assignment deadlines, being important sources of emotional support, helping to reduce stress, and being a welcome distraction and sense of relief, which in turn helped them to stay in university and to complete their academic work:

> "*I'm in my last year of university now, but erm, I've had to take interruptions and so many extensions and things like that just because I couldn't cope with it. And since I've now got him, I've come back to university, I've handed in assignments on time, and I found it altogether less stressful*" (Leith).
>
> "*I think during that time [exams] my partner's dog like, really helped and just sort of being with them, spending time with them, just taking my mind off exams … like the day that I had erm sort of finished my exams, I went to see my partner and his dog as well, and it was just nice to have that sense of relief, and also seeing the dog as well and just experiencing that happiness with them, almost like sharing it with them in a way*" (Osla).

Being a "*consistent*" source of support, spending time together, and increasing a sense of mindfulness or distraction away from worry and stress were important for completing assignments and for coping with multiple life stressors and worry about university:

> "*Like I've had different stresses over the years, you know, like work and that kind of thing. Urm and she's [dog] always, she's always there. She's a consistent help*" (Skye).
> "*I'd come back from like classes and I just sit with her all day. And she'd sit with me, even while I was doing assignments and she generally just keep, like, you know, made me feel better*" (Edina).
> "*A lot of my problems that I'm thinking about, like work stresses, kind of disappear or kind of my mind is taken off and just kind of focused on him [dog]*" (Blair).

A pet's ability to understand and respond to human emotions as well as their "*checking*" behavior were also important for stress relief during difficult life periods and academic study:

> "*There's been times where I've been, like, quite like heightened stress, and he [dog] definitely picks up on it and you know, like, comes over and like, sort of like checks if you're OK*" (Shona).
> "*When they do wanna cuddle up with me, I actually get that sense of calm. Coz college at the minute, it's been very stressful. I've been very stressed. So, when I go home, it's a nice relief to see them there and that they're happy to then come and sit with me*" (Lola).

Skye spoke about how her cat motivated her to continue with her studies as the qualification would help her to find a job and ultimately provide financially for her cat:

> "*Having my cat around gave me a reason to keep going with the course like that, because I need to take care of the cat. And you know, I need to think about the future as well and so somehow I would want to be responsible and like, try to complete the course and (stuff), not dropping out and urm like a giving the cat away*" (Skye).

For one of the neurodiverse young adults, Edina, who had difficulties with school due to severe social anxiety, her dog was an important stress reliever and helped to increase her coping ability and provided a more positive outlook:

> "*I was generally always anxious that I you know, gonna have like a mental breakdown, but then every time I come back from classes and then I would take the dogs for a walk, and it would just feel better by itself. It was sort of like the dogs were giving me some like, you know, internal like release of like stress that I was like, OK, you know, I'm walking these dogs and like, you know life can't get better than this. I don't really have to worry about uni, it's gonna work out. And it was just like, you know, really help me feel better*" (Edina).

Lastly, there were quite strong beliefs about pets' ability to positively change their lives and enable positive futures. One young adult in particular, Leith, spoke in detail about her dog making her "*a different person*", helping her to pursue both work and education, providing a sense of hope and optimism about the future:

> "*I think I just really just really want to emphasize, you know, especially with my dog, you know? Because I feel like I can't emphasize it enough the difference he's made. Like if I look back at the person I was, you know, last year before I got him, it's a completely different person to who I am now. I've managed to now get a job you know, as well as doing university and hopefully graduating in September and you know, I look back like last year and I used to think these things weren't gonna be possible for me. And so it's just, you know, it's just amazing. The difference he has made to me*" (Leith).

4 Discussion

This study has provided an in-depth understanding of young adults' lived experience of how their companion animals impact their symptoms of anxiety and depression. Several perceived underpinning mechanisms (which span across several outcomes/themes) explaining such effects were identified and could be tested within future quantitative studies. First, it is important to acknowledge that the young adults in our study reported quite severe mental health difficulties despite having their pets yet also displayed strong beliefs surrounding the beneficial impact of their animals for the reduction of symptom severity and the management of symptoms. Strong language was used around the perceived impact of pets, such as "always", "definitely", "massive", "absolutely", and "amazing for mental health". However, it was mentioned that perhaps pets provided temporary relief from psychological distress, such as providing symptom relief in the moment of pet interaction, rather than long-term symptom prevention, possibly explaining the inconclusive evidence found in quantitative correlational studies (17, 34). Despite this potential temporary sense of mental health impact, several important perceived benefits in relation to pets and mental health were reported that are noteworthy.

Generalized anxiety symptoms were commonly reported by the young adults in our study, and pets were perceived to reduce such symptoms in several key ways: first, through physiological pathways such as regulating breathing and emotion regulation and lowering physiological arousal (e.g., through touch and petting), helping young adults to feel calmer and more relaxed (e.g., through physical affection), which helped to de-escalate panic attacks, in line with previously proposed biological and physiological benefits of pets (35, 36) and therapy animals (37). The findings relating to pets' ability to help regulate negative emotions, stabilize mood swings, and increase positive mood are in line with developmental studies with children (38) and adolescents (39). Through such calming effects, pets also help to increase mindfulness and the ability to be "present" and "in the moment", which is important for anxiety management (40). Pets also modify attention away from worry and rumination, negative thinking patterns, and harmful thoughts, all of which contribute to the maintenance of anxiety and depression (41, 42). Such harmful thoughts often included self-harm and suicide, and young adults viewed their pets as an important source of attachment and protection (e.g., through a pet's "watching" behavior and proximity), providing a sense of safety, security, and reassurance, preventing harmful thoughts and actions, and thus preventing future admissions to hospital or inpatient units. This sense of safety and security was also important for anxiety and fear management. A pet's ability to prevent harmful thoughts was further facilitated through an increased sense of hope, focus, and motivation to "carry on" and through providing a "reason to live". Our findings, therefore, demonstrate the important role that animals can play in suicide prevention and animals' role in keeping young adults safe, supporting previous research with both neurotypical and neurodiverse adults (43–45). However, one participant mentioned increased suicidal thoughts following pet bereavement, so further support is needed for young adults experiencing the loss of a pet, such as the development of effective coping mechanisms (46).

Social anxiety and reported loneliness were common among our young adult sample, and pets, particularly dogs, were perceived to provide social benefits through facilitating social interactions (e.g., including pets within social interactions) and through promoting favorable social support relationships and feelings of social connectedness, supporting previous evidence of the "social catalyst" effects of pets that can bolster mental health (47, 48). However, social withdrawal was also commonly reported due to low mood, and pets enabled young adults to politely disengage from social interaction when they were feeling overwhelmed; this was particularly important for neurodiverse participants. During social withdrawal and isolation, both dogs and cats provided important companionship, being readily available when young adults felt too unwell to socialize; thus, pets prevented feelings of isolation and loneliness (although we note that research on the impact of pets on loneliness in adult samples has been inconclusive; 49). Although talking to and confiding in pets have been identified as an important source of support in previous studies, particularly in the absence of human social support (50, 51), for our sample of emerging adults, it was important to receive unconditional and non-judgemental company and affection from pets, without the pressure to verbally communicate, such as being asked to talk about their feelings, thus

demonstrating the unique social and emotional benefits of pets for mental health, compared to human companions.

The young adults in our study felt that both pet dogs and cats were attuned and responsive to their emotions, and this was important for improving low mood; such sensitivity and responsiveness can aid attachment development and have been found to be important for mental health in previous studies with adults (52, 53). Consistency, predictability, proximity, eye contact, and shared meaningful activities (e.g., play) and mutual enjoyment (e.g., enthusiasm during human–pet reunion) are also important for human–pet bonding, particularly for dog owners (52), and were important mechanisms identified by the young adults in our study that explain the mood-enhancing effects of pets. The "mood-boosting" effects of pets were also attributed to the ability of both dogs and cats to increase fun and laughter, thus reducing symptoms of anxiety and depression through comic relief, in line with past human–animal interaction (HAI) (20, 54) and mental health research (55). Feeling loved, cared for, and valued by a pet was also important for young adults, and these mechanisms increased positive emotions and optimism and enabled a more positive outlook, thus further demonstrating pet impact on hedonic and eudaimonic wellbeing (56). Previous research has demonstrated that pets can increase resilience during times of adversity (57), and our study supports this, as young adults reported that their pets aided their ability to cope with worry and daily life stressors as well as more stressful life periods including trauma. This increased coping ability and resilience meant that young adults were more likely to persist with academic studies, which in turn meant more successful and positive futures for them, a novel HAI finding that our study has highlighted.

Our study provides further evidence for the importance of routine and structure for the management of mental health symptoms in young adults that can be provided through pet care; such responsibilities increase a sense of purpose, supporting previous HAI findings with family research and older adults (58, 59). This sense of responsibility facilitated behavioral activation, encouraging young adults to engage in healthy activities such as physical exercise and time in nature, thus enabling them to stay well. It should be noted, however, that physical exercise was not as prominent a theme in our emerging adult data as it has been in other studies with older adults and family studies (60, 61). This may be attributed to the inclusion of companion cats in our study or to the living situations of our sample whereby many young adults lived with parents, meaning potential shared responsibilities such as dog walking. The young adults in our study also reported that through taking care of a pet's needs, they felt more able to keep tabs on their own mental health, acting as a motivator or reminder for self-care and to stay well themselves. Taking care of a pet also increases a sense of independence, self-pride, and achievement, supporting past research with child and adolescent samples (62). These are, therefore, further unique ways in which pet care responsibilities can aid positive mental health.

It is important to consider that those young adults who signed up for the study may have done so because of their strong attachment to and beliefs regarding the positive impacts of pets, as reflected in their personal accounts. This meant that perhaps we were unable to capture weaker bonds and more negative impacts and risks to pets' wellbeing. This limitation has been reflected in the field in general, along with the bias of predominantly female participants, also reflected in our sample. Our study was limited to the UK and participants were predominantly White British. Our sample did include however non-binary and LGBT+ individuals and those who are neurodiverse and underrepresented groups within the HAI field. Future studies should aim to examine both risks and benefits of pets for mental health across more diverse samples, particularly for neurodiverse young adults given the unique findings found in our study (e.g., social disengagement) and previous studies (63, 64). Our study purposively recruited individuals who had difficulties with anxiety and/or depressive symptoms, and most of the sample had a clinical diagnosis of an affective disorder. We were, therefore, able to examine the impact of pets on those with clinical levels of mental health difficulties. Co-diagnoses were common, and so our study offered some insight into other underrepresented mental health difficulties within the field (e.g., borderline personality disorders, eating disorders, and psychosis). However, such insight was limited, as questions were not designed to probe further information given the focus on anxiety and depression, and so further investigation into the role of pets in the management of symptoms for more severe mental health difficulties will be important. Interestingly, our study found that when anxious participants viewed their pets as also being anxious, they found comfort in their perceived mutual understanding and shared identity with the pet. It would, therefore, be interesting to investigate in future whether anthropomorphism (attributing human emotions to animals) plays a role in human and pet health, as well as whether emotions can transfer between owners and pets (e.g., see 65, 66).

A strength of our study is that we examined both dog- and cat-owning young adults, addressing the lack of data regarding mental health and cat ownership (67). Human–cat interactions and activities can differ from those with dogs, and so mental health benefits could also differ. However, most mechanisms identified by young adults in our study (except for social activities and physical activity) applied to both dogs and cats with similar positive impacts being reported. Both dogs and cats could, therefore, be incorporated into mental health self-care plans that aim to manage and reduce symptoms of anxiety and depression. Although out of the scope of the current paper, individual pet temperaments were important to young adults. For example, an energetic dog provided mental health benefits for some, but for others, a quieter, calmer, and more affectionate dog was preferred. Therefore, mental health benefits may depend on additional factors that should be further examined in future studies such as owner preferences (e.g., for certain breeds, personalities, or temperaments). Additional factors could include attitudes (68), perceived compatibility (69), relationship quality (70), specific types of pet activities and interactions (38, 56, 67), and the presence or absence of pet behavioral and health problems (71); these may be more important for mental health than simply comparing pet types (e.g., dogs *vs.* cats). It should be noted that this study was qualitative in nature, so the impacts of pets and potential underlying mechanisms explaining such effects are based on young adults' views and personal experiences, and causation cannot be

determined. It is, therefore, recommended that future large-scale quantitative studies further test the mechanisms identified by the young adults in our study in relation to mental health outcomes.

5 Conclusion

This study found that young adults in the UK perceive dogs and cats to have positive impacts on symptoms of anxiety and depression by providing temporary symptom relief in the moment of pet interaction. Specific mutual activities (e.g., playing and walking), physical affection (e.g., petting), pet availability, attunement, responsiveness, pet behavior (e.g., proximity seeking and eye contact), and social and psychological factors (e.g., sense of safety, positive affect, and mindfulness) provided important symptom relief, were important for keeping well, and played a role in the prevention of self-harm and suicide. The underlying mechanisms (e.g., coping, motivation, and positive outlook) also played a role in positive futures for young adults such as increasing perseverance in academic studies. Longer-term impacts of pets remain unclear, paving the way for more longitudinal designs that incorporate mixed methods for triangulation of data. These findings have relevance for the development and evaluation of mental health interventions and treatment protocols aimed at young adults with mental health difficulties, where companion animals may prove to be effective for symptom management and improvements in positive wellbeing. Ethical issues and the welfare of companion animals should be considered within such mental health care plans. It is also important to consider that pet interaction will not always lead to positive benefits, and individual circumstances (e.g., commitment, expectations, resources, and finances) should be evaluated prior to pet acquisition.

Data availability statement

The datasets presented in this article are not readily available because of participant privacy and ethical considerations. Requests to access the datasets should be directed to roxanne.hawkins@ed.ac.uk.

Ethics statement

The studies involving humans were approved by Clinical Psychology, University of Edinburgh Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

RH: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. CK: Formal analysis, Writing – review & editing. CR: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This project was funded by the Society for Companion Animal Studies (SCAS) Pump Priming Funding Award.

Acknowledgments

A sincere thank-you to all of the young adults who shared their experiences with us for this study. Thank you to Sonya Connelly for her help with the transcription process.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 23 February 2024
DOI 10.3389/fpsyt.2024.1355970

OPEN ACCESS

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RECEIVED 14 December 2023
ACCEPTED 08 February 2024
PUBLISHED 23 February 2024

CITATION
Rodriguez KE, Rispoli M, Kelleher BL, MacLean EL and O'Haire ME (2024) The effects of service dogs for children with autism spectrum disorder and their caregivers: a cross-sectional study. *Front. Psychiatry* 15:1355970. doi: 10.3389/fpsyt.2024.1355970

The effects of service dogs for children with autism spectrum disorder and their caregivers: a cross-sectional study

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Introduction: Service dogs are an increasingly popular complementary intervention for children with autism spectrum disorder. However, despite increasing demand, there remains a lack of empirical research on their potential benefits. The purpose of this study was to evaluate the effects of service dogs on children with autism and their caregivers.

Methods: A total of *N* = 75 families of children with autism were recruited from a non-profit service dog provider in the US, including *n* = 39 families previously placed with a service dog and *n* = 36 families engaging in usual care while on the waitlist. Caregivers completed an online survey containing both self- and proxy-report standardized measures of child, caregiver, and family functioning. Linear regressions modeled the relationship between service dog presence and survey outcomes, controlling for relevant child and caregiver covariates.

Results: Results indicated that having a service dog was associated with significantly better child sleep behaviors, including better sleep initiation and duration and less sleep anxiety/co-sleeping with medium effect sizes. However, service dog presence was not significantly related to child withdrawal, negative emotionality, emotional self-control, hyperactivity, irritability, and lethargy with small effect sizes. For caregivers, having a service dog was not significantly related to standardized measures of caregiver strain, sleep disturbance, depression, or the impact of the child's condition on family functioning with small effect sizes. Supplemental matched case-control analyses confirmed these findings.

Discussion: In conclusion, service dogs were found to positively impact sleep behaviors among children with autism, but may not uniformly relate to other areas of child and caregiver wellbeing. Prospective longitudinal designs, larger sample sizes able to detect small effects, and studies that measure sleep using objective methods are needed to build on these findings.

KEYWORDS

service dog, assistance dog, autism spectrum disorder, animal-assisted intervention, caregivers

1 Introduction

Autism spectrum disorder (ASD; autism) is a developmental condition characterized by persistent impairments in social interaction, verbal and nonverbal communication, and restricted/repetitive behaviors (1). A majority of caregivers of children and adolescents with autism will engage in home- and school-based interventions specific to the individual's needs (2). In addition to evidence-based interventions to improve social skills and/or behavior, a majority of families also report engaging in complementary interventions (3, 4). One example of a complementary intervention for autism is animal-assisted intervention (AAI), a goal-oriented intervention that intentionally includes animals for therapeutic purposes (5).

Research evaluating the efficacy of AAI for children and adolescents with autism suggests that interactions with animals (including but not limited to dogs, horses, or small domestic animals) can significantly improve social interaction and communication (6, 7). While the theorized mechanisms for why animals may improve social outcomes for individuals with autism vary, it is suggested that animals can act as an initial social catalyst, or social bridge, to encourage communication with others (8–10). Research has also found that participation in AAI can result in increases in positive emotion, reductions in physiological stress, and reductions in aggressive behavior (7, 11). In this sense, animals may provide a calming presence, help maintain positive attentional focus, and reduce negative arousal (12–14).

In addition to AAIs, an increasingly popular practice in the autism community is the placement of a service dog (15). Service dogs are trained to perform tasks that directly assist an individual with a disability, including autism (16, 17). While service dogs may be self- or locally-trained, most placements occur by non-profit organizations that procure, train, and place service dogs for a specific disability (15). As of 2022, there are 64 non-profit organizations accredited by Assistance Dog International worldwide that place service dogs specifically for autism (18). These service dogs can be trained to interrupt self-stimulatory or repetitive behaviors, provide calming, deep pressure, and help ameliorate sensory overload. In addition to their trained tasks, service dogs may also benefit individuals with autism by increasing participation in daily activities (e.g., chores, caregiving actions, playing outdoors), assisting with the development and improvement of motor skills (e.g., throwing a ball, petting, and brushing), and facilitating social interactions with peers and the public (19–21).

Some research suggests that service dogs can provide psychological, social, and even physiological benefits for children and adolescents with autism, although findings have been mixed (22). In qualitative interviews, caregivers of children with autism describe that having a service dog has helped prevent or interrupt tantrums, improve sleep behaviors, prevent elopement behavior in public, and act as a calming and comforting presence (19–21, 23, 24). However, quantitative studies have reported mixed findings. A 2021 pilot study compared six families with a service dog to 12 families on a service dog waitlist and found no significant differences between groups on standardized parent-reported measures of child adaptive behavior or child social responsiveness (25). However, the sample size was small presenting challenges for analyses. A recent 2022 study assessing 11 families before and 2-3 months after placement with a service dog found improvements in parent-reported measures of child socioemotional behavior as well as decreases in parent and child physiological stress, but the study did not have a control group (26). In the largest study to date, a longitudinal study with 42 children with autism found that service dog presence was associated with lower cortisol levels and fewer problematic behaviors (27). In summary, although qualitative reports are promising, quantitative studies have produced mixed findings indicating a need for more research in this area (22, 28). Not only are studies needed with larger sample sizes and comparison groups, but it remains unknown how individual differences and circumstances may influence variability in findings (e.g., the child's relationship with the service dog, time with the service dog, or the child's social and communication behaviors).

While families often seek service dogs to benefit a child or adolescent with autism, some research indicates that service dogs can simultaneously benefit the lives of caregivers. Caregivers often serve as the primary handler for autism service dogs, creating a unique triadic relationship between the dog, child, and caregiver. Qualitative studies suggest that service dogs can improve caregivers' quality of life by decreasing stress and providing them with a sense of safety and security (20, 21, 29). In qualitative interviews, caregivers also report that having the service dog in public increases the frequency and duration of family outings and can reduce isolation (19, 24).

However, similar to the literature on child outcomes, quantitative studies on caregiver effects have yielded mixed findings. One recent pilot study found evidence of reduced parenting stress for 11 caregivers of children with autism after 2-3 months with a service dog, but the study did not have a comparison group (26). In a large longitudinal study, 49 caregivers reported less parenting stress after nine months with a service dog compared to 49 caregivers remaining on the waitlist, however, the waitlist group had significantly higher parenting stress at baseline which confounded results (30). In contrast, a 2014 cross-sectional study found no difference in caregiving burden or strain among 134 caregivers of children with autism with a service dog compared to 87 on the waitlist (31). Due to the inconsistencies in findings and the limited number of studies conducted, there remains a need for more research on the effects of service dogs for caregivers and families of children with autism that integrates standardized measures, comparison groups, and large sample sizes. In addition, similar to research on child effects, it is unknown how the caregiver's relationship with the service dog, time with the service dog, or the perceived costs of caring for the service dog may relate to variability in outcomes.

The present study aims to contribute to this literature base to characterize the effects of service dogs for children and adolescents with autism as well as their caregivers and families. The study's aims were to explore the relationship between having a service dog on standardized measures of psychosocial functioning for individuals with autism (Aim 1) and their caregivers (Aim 2). We hypothesized that compared to those on the waitlist to receive a service dog, families with a service dog in the home would exhibit superior

functioning in measured domains. In addition, an exploratory aim (Aim 3) examined how time cohabiting with the service dog, the child-service dog bond, the caregiver-service dog bond, and the perceived costs of the service dog may relate to child and caregiver outcomes.

2 Materials and methods

All protocols were reviewed and approved by the Purdue University Institutional Review Board (IRB Protocol #1906022320). As no interactions with the research team and service dogs occurred, a waiver was obtained from the Purdue University Institutional Animal Care and Use Committee.

2.1 Participants

Participating families were recruited from October 2019 to April 2021 from the database of service dog provider Canine Companions. Canine Companions is a 501(c) (3) non-profit organization accredited by Assistance Dogs International (ADI) which provides service and assistance dogs, including those for autism, free of cost to families across the US. Service dogs placed for autism are trained for various tasks, including retrieving, carrying, and delivering dropped items, responding to periods of self-stimulatory behavior, providing calming deep pressure, and performing interactive commands to promote social engagement with the child. Canine Companions service dogs are purpose-bred Labrador retrievers, Golden retrievers, or Labrador-Golden retriever crosses that follow ADI standards regarding canine health, temperament, and behavior. Canine Companions closely monitors and evaluates the health and welfare of service dogs both pre- and post-placement.

All child and caregiver participants recruited from Canine Companions had already been screened, interviewed, and approved to receive a service dog from the organization. Inclusion criteria to receive a service dog from Canine Companions includes caregiver age of at least 18 years old, child age of at least five years old, and a child diagnosis of an intellectual or developmental disability from a medical, psychological, or educational professional, which was self-reported by the caregiver. Inclusion criteria to be eligible to participate in the research study included child age of 5-18 years old and documentation of an autism diagnosis, including DSM-5 diagnoses of autism spectrum disorder as well as previous DSM iterations of Autistic disorder, Asperger syndrome, pervasive developmental disorder (PDD), or pervasive developmental disorder not otherwise specified (PDD-NOS).

The sample included families already placed with a service dog for a minimum of six months prior to recruitment in the study (*service dog group; n* = 39*)* and those on the waitlist to receive a service dog (*comparison group; n* = 36). Both groups received unrestricted access to usual care. Among the service dog group, time since placement ranged from 0.52 – 7.39 years (M = 3.68, SD = 1.99). The decision to exclude families with more recent placements (<6 months) was to ensure that any initial adjustment period had passed (25, 32). Time spent on the waitlist was not collected, but the average waiting time for the organization is roughly 1-2 years. Demographics for the sample of N = 75 families are displayed in Table 1, which were obtained via caregiver-report. Children were predominantly male (72%), with an average age of 11.25 years and range of 5-17. Average Social Communication Questionnaire (SCQ; see section 2.3.1) scores were 18.06 (SD = 5.89) across the total sample, with n = 63 of the 69 valid SCQ scores over the suggested cutoff of 10 for a likely autism screening (33). A majority of children had an associated condition in addition to an autism diagnosis, including limited verbal ability (75%), developmental delay (60%), learning disability (49%) and attention deficits (49%). The most common treatment services engaged in were speech and language therapy (61%), occupational therapy (48%), applied behavior analysis (43%), social skills training (20%), and parent-implemented interventions (20%). A subset of children took medications, including stimulants (28%), antidepressants (28%), antipsychotics (12%), anticonvulsants (15%), and antianxiety medications (15%). Children were mostly engaging in special education (45%) followed by general education (20%), part-time general/special education (19%), or home education (16%).

2.2 Procedures

A Canine Companions staff member contacted eligible caregivers from both the service dog group and the comparison group to ask for consent to share their information with the research team. The research team then directly communicated with participants to share study information and obtain verbal consent (caregivers) and assent (for children older than 12) to participate in the study. Caregiver participation consisted of completing an online survey via Qualtrics and collecting saliva samples from their child on three mornings (data reported separately). Caregivers were assured that neither their participation nor responses in the study would be shared with Canine Companions to ensure unbiased reporting. Participants were compensated $40 for survey completion. The recruitment rate was 84% (81 families consented to participate from 97 contacted), and the survey participation rate was 93% (75 families completed survey from 81 consented).

2.3 Survey measures

Demographic information collected for caregiver participants included age, gender identity, caregiving role, race/ethnicity, family size, presence of a pet dog in the home, employment, relationship status, annual household income, and level of education. Demographic information collected for child participants included child age, gender identity, associated conditions, participation in school or day programs, current treatments, and current medications taken.

TABLE 1 Demographic characteristics of N = 75 participating families.

	Group			Group difference	
	Service Dog (*n* = 39)	Comparison (*n* = 36)	Total (*N* = 75)	*t* or X^2	*p*
Child Demographics					
Age, *M (SD)*	12.92 (2.89)	9.44 (3.12)	11.25 (3.46)	5.014	<0.001
Male gender, *n* (%)	25 (64%)	29 (81%)	54 (72%)	2.514	0.113
SCQ, *M (SD)*	17.67 (5.68)	18.48 (6.17)	18.06 (5.89)	-0.573	0.568
Hours of education services per week, *M (SD)*	19.33 (13.19)	19.74 (11.66)	19.53 (12.39)	-0.408	0.684
Hours of treatment services per week, *M (SD)*	16.96 (31.39)	17.25 (36.87)	17.10 (33.86)	0.032	0.974
Caregiver Demographics					
Age, *M (SD)*	45.36 (5.41)	43.03 (6.18)	44.24 (5.87)	1.742	0.086
Female gender, *n* (%)	35 (90%)	34 (94%)	69 (92%)	0.562	0.453
# Children in home, *M (SD)*	1.85 (1.04)	1.97 (1.61)	1.91 (1.34)	-0.406	0.686
Pet dog in home, *n* (%)	13 (33%)	7 (19%)	20 (27%)	1.847	0.174
Race, *n* (%)				2.190	0.701
White	33 (85%)	26 (72%)	59 (79%)		
More than one race	3 (8%)	4 (11%)	7 (9%)		
Asian	1 (3%)	3 (8%)	4 (5%)		
Black or African American	1 (3%)	2 (6%)	3 (4%)		
American Indian/Alaskan Native	–	–	–		
Native Hawaiian or Pacific Islander	–	–	–		
Prefer not to say	1 (3%)	1 (3%)	2 (3%)		
Ethnicity, *n* (%)				1.131	0.568
Not Hispanic or Latino	34 (87%)	31 (86%)	65 (87%)		
Hispanic or Latino	4 (10%)	5 (14%)	9 (12%)		
Prefer not to say	1 (3%)	–	1 (1%)		
Education, *n* (%)				3.911	0.562
Post-graduate degree	20 (51%)	21 (58%)	41 (55%)		
4-year college degree	10 (26%)	10 (28%)	20 (27%)		
2-year college degree	5 (13%)	1 (3%)	6 (8%)		
Some college	2 (5%)	2 (6%)	4 (5%)		
High school/GED	1 (3%)	2 (6%)	3 (4%)		
Some high school	1 (3%)	–	1 (1%)		
Prefer not to say	–	–	–		
Annual Household Income, n (%)				3.943	0.684
Less than $25,000	1 (3%)	1 (3%)	2 (3%)		
$25,000 - $49,999	3 (8%)	1 (3%)	4 (5%)		
$50,000 - $74,999	4 (10%)	1 (3%)	5 (7%)		
$75,000 - $99,999	7 (18%)	8 (22%)	15 (20%)		
$100,000 - $124,999	4 (10%)	6 (17%)	10 (13%)		

(Continued)

TABLE 1 Continued

	Group			Group difference	
	Service Dog (n = 39)	Comparison (n = 36)	Total (N = 75)	t or X^2	p
Caregiver Demographics					
$125,000 or above	17 (44%)	14 (39%)	31 (41%)		
Prefer not to say	3 (8%)	5 (14%)	8 (11%)		
Relationship Status, n (%)				8.955	0.062
Married	34 (87%)	32 (89%)	66 (88%)		
Divorced	5 (13%)	–	5 (7%)		
Widowed	–	2 (6%)	2 (3%)		
Single (never married)	–	1 (3%)	1 (1%)		
Living with significant other	–	–	–		
Separated	–	–	–		
Prefer not to say	–	1 (3%)	1 (1%)		
Employment, n (%)				3.187	0.562
Full-time	17 (44%)	19 (53%)	36 (48%)		
Part-time	11 (28%)	10 (28%)	21 (28%)		
Unemployed	9 (23%)	5 (14%)	14 (19%)		
Disabled or Retired	1 (3%)	1 (3%)	2 (3%)		
Prefer not to say	1 (3%)	1 (3%)	2 (3%)		

M, mean; SD, standard deviation; n, partial sample size; N, total sample size.

2.3.1 Child measures

The lifetime version of the Social Communication Questionnaire (SCQ; Chandler et al., 2007) was used to describe autism symptomology. The SCQ is a 40-item proxy-report questionnaire appropriate for both verbal and non-verbal children four years of age and older (34). Each item asks caregivers to report if their child experiences or exhibits a certain behavior with dichotomous response options (0, "No"; 1, "Yes"). For children with caregiver-reported language ability, summed scores range from 0 to 39, with a higher score indicating more severe autism symptoms. For children without language ability, summed scores range from 0 to 33. Scores of >15 indicate a potential identification on the autism spectrum. The SCQ had acceptable internal reliability (Cronbach's α = 0.78). SCQ scores were not calculated for those with any missing data on the measure (occurring for n = 6 participants). No exclusions were made based on SCQ scores, as the SCQ is a screening measure rather than a diagnostic measure (35) and demonstrates reduced sensitivity and specificity among children and adolescents with co-occurring mental and behavioral diagnoses (33).

The Children's Sleep Habit Questionnaire (CSHQ; 36) modified for children with autism (37) measured child sleep habits and behaviors. The modified 23-item scale has four subscales: sleep initiation and duration (SID), sleep anxiety/co-sleeping (SACS), night waking/parasomnias (NWP), and daytime alertness (DA). Caregivers were asked to indicate how often their child engaged in a range of sleep-related behaviors in the past week or typical week on a 5-point Likert scale, with a higher score indicative of worse sleep habits and behaviors. The modified CSHQ had good internal reliability (α = 0.85).

Behavioral and emotional difficulties were operationalized with two measures. First, the Aberrant Behavior Checklist (ABC; 38) measured children's disruptive behaviors with the subscales of irritability, social withdrawal, and hyperactivity/noncompliance (47 items total). Questions asked caregivers to indicate the severity of child behaviors over the past four weeks on a 4-point Likert scale, with a higher score indicative of greater severity. The ABC had excellent internal reliability (α = 0.92). Second, The Behavior Assessment Scale for Children 3rd edition (BASC-3; 39) measured child emotional behavior with the subscales of negative emotionality, withdrawal, and emotional self-control (24 items total). Questions asked caregivers to indicate the frequency with which the child has displayed behaviors "in the past several months" on a 4-point Likert scale, with a higher score indicative of higher frequency. The BASC had good internal reliability (α = 0.85). A BASC score was not calculated for n = 1 participant due to missing data.

The child's quality of peer relationships was measured via the PROMIS® (Patient-Reported Outcomes Measurement Information System; 40) Peer Relationships Pediatric Parent-Proxy Short Form (7-A v2.0). This 7-item measure asked caregivers to indicate the frequency with which their child engaged in social behaviors in the

past week with peers on a 5-point Likert scale with higher scores indicating higher quality and quantity of peer relationships. This measure has been previously validated as an efficient and valid measure of peer relationships among youth with ASD (41). Scores were transformed to normative t-scores according to the PROMIS scoring manual with a population mean of 50 and standard deviation of 10. This measure had excellent internal reliability ($\alpha = 0.93$).

2.3.2 Caregiver measures

The Caregiver Strain Questionnaire (CGSQ; 42) measured caregiver strain. This 21-item measure has three subscales: Objective strain (OS), subjective externalized strain (SES), and subjective internalized strain (SIS). The three subscale scores are added to create a global score. Caregivers were asked about strain for themselves and/or their family in the past six months "as a result of their child's emotional or behavioral problems" on a 5-point Likert scale, with higher scores indicative of higher caregiver strain. The CGSQ had excellent internal reliability ($\alpha = 0.93$).

The PROMIS® Sleep Disturbance Short Form 6-A (43) measured caregiver self-reported perceptions of sleep quality, sleep depth, and restoration associated with sleep. Caregivers reported on their sleep in the past week on a 5-point Likert scale, with higher scores indicative of worse sleep disturbance. Items were summed and transformed to normative t-scores according to the PROMIS scoring manual with a population mean of 50 and standard deviation of 10. The measure had good internal reliability ($\alpha = 0.89$).

The Patient Health Questionnaire-9 (PHQ-9; 44) measured caregiver depression. This 10-item measure asked caregivers to indicate if they had been bothered by nine problems over the past two weeks on a 4-point Likert scale, with higher score indicative of more depression symptoms. The final item asked about the perceived difficulty of these problems interfering with daily life. The PHQ-9 had excellent reliability ($\alpha = 0.90$).

The PedsQL™ (Pediatric Quality of Life Inventory) Family Impact Module Family Functioning Scale (45) measured caregiver-reported family functioning. The scale has two subscales: Daily Activities and Family Relationships. Caregivers were asked to indicate how often their family has faced a range of concerns and difficulties due to their child's health in the past month on a 5-point Likert scale. Items were reverse-scored and linearly transformed to a 0–100 scale such that higher scores indicated better family functioning and less negative impact. This measure had excellent internal reliability ($\alpha = 0.90$).

2.3.3 Human-animal bond measures

Human-animal bond measures were given to the service dog group only. The Monash Dog-Owner Relationship Scale (MDORS; 46) perceived costs (PC) subscale measured the caregiver's perceived costs of having a service dog. This 9-item subscale asked caregivers to indicate how inconvenient they perceived caring for and living with the service dog to be. Questions were scored on a 5-point Likert scale and summed such that higher scores indicated more perceived costs. The MDORS PC subscale had excellent internal reliability ($\alpha = 0.92$).

The human-animal bond was operationalized with two scales intended to measure perceived closeness with the service dog in two distinct ways. First, the Monash Dog-Owner Relationship Scale (MDORS; 46) emotional closeness (EC) 10-item subscale measured the emotional closeness between the child and service dog as well as between the caregiver and service dog. The MDORS has been used in several studies of service dog-handler dyads (e.g., 47, 48) A higher score indicated higher child-service dog or caregiver-service dog emotional closeness. The MDORS EC subscale had good internal reliability (caregiver $\alpha = 0.87$; child $\alpha = 0.91$).

Second, the Inclusion of Other in Self (IOS) scale (49) measured the perceived interpersonal closeness, or interconnectedness, between the child/caregiver and service dog. The IOS is a single-item pictorial scale containing seven pairs of increasingly overlapping circles ranging from touching but not overlapping (1) to completely overlapping (7). The IOS has been used as a measure of the human-animal bond with both pet dog-owner dyads (e.g., 50) and service dog-handler dyads (e.g., 51). The IOS was chosen to complement the MDORS EC scale as it captures a purely subjective sense of closeness consistent with theoretical orientations of relationship psychology (52). In contrast, the MDORS EC subscale asks more objective questions to measure closeness such as frequency of specific behaviors and actions. Although the IOS and MDORS EC were significantly correlated (caregiver-dog: $\rho = 0.517$ $p = < 0.001$; child-dog $\rho = 0.808$, $p < 0.001$), measures were independently analyzed due to their unique conceptualization of closeness with the service dog.

2.4 Statistical analyses

All analyses were conducted in IBM SPSS version 28.0. First, demographic characteristics among children and caregivers in the service dog and comparison groups were compared using independent *t*-tests for continuous variables and chi-squared tests for categorical variables. Group-level statistics indicated that most demographic variables were not statistically different across groups. However, the service dog group was significantly older than the waitlist comparison group (M = 12.92 v. M = 9.44, $t = 5.014$, $p < 0.001$), had less prevalence of co-occurring developmental delay (49% vs. 72%, $X^{2} = 4.309$, $p = 0.038$), and had higher use of antidepressants (39% vs 17%, $X^{2} = 4.141$, $p = 0.036$). Therefore, these three variables were considered as covariates in statistical models.

Survey measures were examined for normality, and logarithmic transformations were performed for eight variables with a skewness statistic greater than twice its standard error (CSHQ Total, CSHQ SID, CSHQ SACS, CSHQ DA, CSHQ NWP, ABC Lethargy, PHQ, and CGSQ_SES). Multiple linear regression models were used to assess the association between service dog presence with child and caregiver measures. Survey measures were treated as dependent variables, while independent variables consisted of having a service dog or not (0, no; 1, yes) and child/caregiver covariates. Covariate inclusion was based on theoretical relevance to psychosocial outcomes and demographic variables in which significant group differences were found. For child models, covariates considered included gender identity (0, male; 1, female), age (continuous),

presence of a developmental delay (0, no; 1, yes), and antidepressant use (0, no; 1, yes). For caregiver models, covariates considered included gender (0, female; 1, male), the number of children in the home (continuous), relationship status (0, not married or prefer not to say; 1, married), annual household income category (ordinal), and child autism severity as measured via the SCQ (continuous). To maximize power and ensure model parsimony, only covariates that were significant predictors at $p < 0.10$ were retained.

All models were checked for homoscedasticity, multicollinearity, and normality of residuals. A *post-hoc* power analysis conducted using G*Power (53) confirmed that the sample size ($N = 75$) was sufficient to achieve power of 0.91 to detect a medium effect ($f^2 = 0.15$) of the tested predictor (service dog presence) at an error probability of $\alpha = .05$ with four predictors, which was the maximum number of predictors included across all models. We reported partial R^2 as a measure of effect size, which describes the residual variance in each child or caregiver outcome explained by the service dog predictor. Partial R^2 effect sizes were interpreted as small (< 0.02), medium (0.03 to 0.13), and large (> 0.14).

In consideration of bias due to the imbalance of confounding variables across the service dog and comparison group, supplemental analyses were conducted with a subset of matched participants. Matched groups of $n = 24$ in each group were created with SPSS case-control matching function on child age (tolerance of 2 years) and child gender (exact). Independent *t*-tests for continuous variables and chi-squared tests for categorical variables confirmed that demographic characteristics were equal across matched groups. Independent *t*-tests were then used to describe the association between service dog presence with child and caregiver measures.

Lastly, an exploratory aim assessed the relationship between service dog-related variables and child and caregiver outcomes among the *service dog* group only. Pearson's bivariate correlations were conducted with child/caregiver measures and time since service dog placement, child-service dog emotional closeness (MDORS EC), caregiver-service dog emotional closeness (MDORS EC), and perceived costs of caring for the service dog (MDORS PC), which were all continuous interval variables. Nonparametric Spearman's correlations were conducted with child/caregiver measures and child-dog and caregiver-dog interconnectedness (IOS), which was an ordinal variable.

3 Results

Table 2 contains descriptive statistics for all child and caregiver survey measures. After controlling for covariates, there was a significant effect of having a service dog on child sleep habits and sleep behavior. Specifically, having a service dog was associated with significantly lower CSHQ scores (indicating better sleep outcomes; $p = 0.038$, medium effect size) including significantly better sleep initiation and duration ($p = 0.005$, medium effect size) and sleep anxiety/co-sleeping ($p = 0.026$, medium effect size). There was no significant effect of having a service dog on the CSHQ subscales of night waking/parasomnias or daytime alertness ($ps > 0.380$, small effect sizes). Service dog presence was not significantly related to child hyperactivity, irritability, and lethargy as assessed via the ABC ($ps > 0.234$), child emotional self-control, withdrawal, and negative emotionality as assessed via the BASC ($ps > 0.184$), or quality of the child's peer relationships ($p = 0.209$; all small effect sizes). For caregivers, there was no significant relationship between service dog presence and total caregiving strain via the CGSQ, nor any of its three subscales (OS, $p = 0.558$, SES, $p = 0.563$, SIS, $p = 0.416$). There was also no significant relationship between service dog presence and caregiver sleep disturbance or depression symptoms ($ps > 0.506$) nor familial impacts due to the child's health in terms of the family's daily activities or family relationships ($ps > 0.472$; all small effect sizes).

Supplemental analyses with the matched sample ($n = 24$ per group) showed identical findings to the above. Specifically, independent *t*-tests showed a significant association with service dog presence and total CSHQ scores ($t(45) = -2.366$, $p = 0.011$), CSHQ sleep initiation and duration ($t(46) = -2.526$, $p = 0.008$), and CSHQ sleep anxiety/co-sleeping ($t(45) = -2.421$, $p = 0.011$). However, there were no significant associations with service dog presence and all other child and caregiver survey measures ($ps > 0.059$). Full data from supplementary analyses are available upon request from authors.

3.1 Service dog group exploratory analyses

Exploratory analyses evaluated the relationship between time cohabiting with the service dog, the child-service dog bond, the caregiver-service dog bond, and the perceived costs of the service dog with child and caregiver outcomes (Table 3). The first variable examined was the time since service dog placement. There were no significant correlations between the time since the service dog was placed and any of the child ($ps > 0.089$) or caregiver ($ps > 0.165$) survey measures. Time since service dog placement was negatively correlated with child-dog emotional closeness ($p = 0.010$), child-dog interconnectedness ($p = 0.006$), and caregiver-dog emotional closeness ($p = 0.014$) such that newer service dog placements were associated with stronger child-dog and caregiver-dog bonds.

The second exploratory variable examined was the strength of the child-dog bond via emotional closeness (MDORS EC; $M = 39.92/50$, $SD = 7.96$) and interconnectedness (IOS; $M = 4.97/7$, $SD = 1.71$). Children with lower SCQ scores (indicating better communication skills and social functioning) were rated as more emotionally close with their service dog ($p = 0.018$) than children with higher SCQ scores. Children with less severe irritability on the ABC were rated as more emotionally close with their service dog ($p = 0.024$) and had higher interconnectedness with their service dog ($p = 0.017$). Children with a higher quality of peer relationships were rated as more emotionally close with their service dog ($p = 0.024$). Finally, children rated as more emotionally close with their service dog had worse sleep habits and behaviors ($p = 0.020$), including more sleep anxiety and co-sleeping behavior ($p = 0.036$) and more night waking and parasomnias ($p = 0.010$).

The last variable examined was the strength of the caregiver-dog bond via emotional closeness. (MDORS EC; $M = 36.46$, $SD = 6.59$), interconnectedness (IOS; $M = 4.41$, $SD = 1.41$), and perceived costs

TABLE 2 Descriptive statistics and linear regression results of child and caregiver measures.

	Service Dog (n = 39)	Comparison (n = 36)	Service Dog Effect[a]		
Child Measures	*M (SD)*	*M (SD)*	*B*	*Partial R^2*	*p*
ABC Hyperactivity	18.03 (9.76)	21.56 (10.13)	0.048	0.002	0.696
ABC Irritability	13.46 (7.49)	13.64 (7.53)	0.157	0.018	0.234
ABC Lethargy	11.56 (8.98)	11.86 (7.82)	0.029	0.001	0.800
BASC Emotional Self-Control	12.69 (5.61)	12.64 (5.58)	0.088	0.006	0.506
BASC Withdrawal	14.26 (6.34)	14.14 (6.09)	-0.174	0.022	0.184
BASC Negative Emotionality	6.41 (3.73)	6.53 (3.03)	0.013	0.000	0.922
PROMIS Peer Relationships	31.79 (8.21)	31.56 (8.20)	0.169	0.021	0.209
Children's Sleep Habit Questionnaire	33.26 (6.46)	37.00 (8.24)	-0.242	0.058	0.038*
Sleep Initiation and Duration	8.36 (2.37)	9.47 (2.51)	-0.377	0.106	0.005**
Sleep Anxiety/Co-Sleeping	5.82 (1.64)	8.31 (3.43)	-0.269	0.053	0.026*
Night Waking/Parasomnias	9.51 (2.81)	10.03 (2.93)	-0.090	0.008	0.444
Daytime Alertness	9.56 (3.19)	9.31 (2.92)	-0.117	0.010	0.380
Caregiver Measures	*M (SD)*	*M (SD)*	*B*	*Partial R^2*	*p*
Caregiver Strain Questionnaire	7.80 (2.04)	8.05 (2.35)	-0.056	0.003	0.631
PROMIS Sleep Disturbance	52.47 (8.50)	53.74 (7.79)	-0.078	0.006	0.506
Patient Health Questionnaire	5.23 (4.97)	5.42 (4.90)	-0.066	0.004	0.564
PedsQL Family Impact - Daily Activities	41.24 (17.72)	42.59 (28.09)	-0.038	0.001	0.741
PedsQL Family Impact - Family Relationships	65.64 (21.28)	61.81 (27.49)	0.091	0.008	0.442

M, mean; SD, standard deviation; B, standardized regression coefficient; ABC, Aberrant Behavior Checklist; BASC, Behavior Assessment Scale for Children; PROMIS, Patient-Reported. Outcomes Measurement Information System; PedsQL, Pediatric Quality of Life Inventory; *, $p < 0.05$; **, $p < 0.01$.
[a]Reference category: waitlist (assistance dog=1; waitlist=0).

of caring for the service dog (MDORS PC; M = 12.77, SD = 5.67). Caregiver-dog and child-dog emotional closeness were significantly correlated (p = 0.016), but interconnectedness was not (p = 0.460). Caregivers with higher emotional closeness to the service dog reported more negative impacts of the child's health on daily activities (p = 0.014) and family relationships (p = 0.017). Caregivers with higher interconnectedness with the service dog reported fewer depressive symptoms (p = 0.030). Finally, caregivers that reported more perceived costs of caring for the service dog reported higher caregiver strain (p = 0.042).

4 Discussion

This study aimed to evaluate the effects of service dogs on children with autism and their caregivers. Using a cross-sectional design, we compared families of children with autism with a service dog to families on the waitlist, both of which were receiving usual care. After controlling for child and caregiver covariates, having a service dog was significantly associated with better child sleep behaviors, including better sleep initiation and duration and less sleep anxiety/co-sleeping behaviors with medium effect sizes observed. However, service dog presence was not significantly associated with child social and emotional behaviors, child peer relationships, caregiving strain, caregiver sleep, and family functioning, with small effect sizes observed. We discuss these results in depth below.

4.1 Child findings

Results of the current study found that living with a service dog was associated with significantly better parent-reported sleep initiation and duration and less sleep anxiety/co-sleeping among children with autism. These findings align with qualitative studies describing how children are more likely to sleep through the night due to a service dog's presence in their room or bed (24, 26) and are willing to stay in their room by themselves (20). Our results support the hypothesis that service dogs provide a sense of security and comfort to a child with autism at night, which may translate into exhibiting less sleep anxiety and co-sleeping behavior with a caregiver. Curiously, although the service dog group reported better sleep outcomes on average, within-group analyses suggest that children who were more emotionally close to their service dogs had worse sleep outcomes. However, this finding is correlational, not causational; it may be that children who are struggling with

TABLE 3 Bivariate correlations between child and caregiver measures and service dog-related variables among *n* = 39 families with an assistance dog.

	Child-Dog Bond			
Child Measures	Time Since Placement	MDORS EC	IOS	
Social Communication Questionnaire	—	-0.391 *	—	
ABC Hyperactivity	—	—	—	
ABC Irritability	—	-0.366 *	-0.380 *	
ABC Lethargy	—	—	—	
BASC Emotional Self-Control	—	—	—	
BASC Withdrawal	—	—	—	
BASC Negative Emotionality	—	—	—	
PROMIS Peer Relationships	—	0.362 *	—	
Children's Sleep Habit Questionnaire	—	0.377 *	—	
Sleep Initiation and Duration	—	—	—	
Sleep Anxiety/Co-Sleeping	—	0.341 *	—	
Night Waking/Parasomnias	—	0.415 **	—	
Daytime Alertness	—	—	—	
MDORS Child-Dog Emotional Closeness	-0.415 **			
IOS Child-Dog Interconnectedness	-0.430 **	0.810 ***		
	Caregiver-Dog Bond			
Caregiver Measures	Time Since Placement	MDORS EC	IOS	Perceived Costs
Caregiver Strain Questionnaire	—	—	—	0.332 *
PROMIS Sleep Disturbance	—	—	—	—
Patient Health Questionnaire	—	—	-0.349 *	—
PedsQL Family Impact - Daily Activities	—	-0.391 *	—	—
PedsQL Family Impact - Family Relationships	—	-0.379 *	—	—
MDORS Caregiver-Dog Emotional Closeness	-0.391 *			
IOS Caregiver-Dog Interconnectedness	—	0.524 ***		
MDORS Caregiver-Dog Perceived Costs	—	—	—	

ABC, Aberrant Behavior Checklist; BASC, Behavior Assessment Scale for Children; PROMIS, Patient-Reported Outcomes Measurement Information System; PedsQL, Pediatric Quality of Life Inventory; MDORS EC, Monash Dog-Owner Relationship Scale Emotional Closeness subscale; IOS, Inclusion of Other in Self Scale; —, Not significant; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$
Grey boxes indicate where a variable is being correlated with itself, thus no value is shown.

sleep seek out more of a connection or develop a closer bond with their service dogs. Future research will benefit from examining sleep more closely in this population, including assessing the service dog's effect on sleep quality, awakenings, and duration using objective methods, as well as examining the role of the child-service dog bond on outcomes in longitudinal designs.

Contrary to our hypothesis, having a service dog had no significant association with child and adolescent social withdrawal, irritability, or hyperactivity behaviors via the ABC or negative emotionality, withdrawal, and emotional self-control behaviors via the BASC. Notably, the sample size was not powered to detect small effects, and the heterogeneity of the child sample likely contributed to high variability that may have also obscured a small effect. While some qualitative studies have described improvements in child and adolescent social and emotional behavior after being placed with an autism service dog (20, 21, 23, 24), these benefits may be too variable across individuals to capture in a group comparison design, especially considering the large range in child behavior due to the spectrum nature of autism. In addition, socioemotional behaviors among children with autism have subtle variations in quality and frequency, making it hard to reliably measure change (54). Future research will benefit from considering a clustering approach to explore how specific autism phenotypes may respond differently to a service dog intervention (55, 56), integrating longitudinal, within-person designs, and larger sample sizes to detect small effects.

Contrary to our hypothesis, there was no significant relationship between having a service dog and the quality of children/adolescents' peer relationships via the PROMIS Peer Relationships scale. However, it is notable that both service dog and waitlist groups had scores that were almost two standard deviations below the population mean of 50 (mean t-scores of 31.56 and 31.79, respectively), indicating the quality and quantity of peer relationships to be low in the current sample. Due to the limitations in caregiver report, it is possible that this measure did not capture the subtle social facilitation effects that may occur while children are at school or away from home (41). Given the social facilitation effects that service dogs (57, 58) and therapy dogs (59) have been reported to provide to children with autism, future research will benefit from complementing caregiver-report scales with teacher-report scales and observational measures (e.g., 10) or incorporating other types of social facilitation measures.

For families with a service dog, indicators of the child-dog bond were high and similar to other service dog populations (e.g., 60). Interestingly, correlational analyses found newer service dog placements were associated with stronger child-dog and caregiver-dog bonds. This may be due to a novelty effect such that excitement and initial engagement with the service dog could lead to higher perceptions of closeness, which may stabilize over time. Qualitative studies have described how some children form immediate strong bonds with their service dogs while others may take more time due to physical or social constraints (19, 61). Future, longitudinal research will be valuable to examine how the child-dog bond forms and changes over time. Correlational analyses also found that children with lower SCQ scores (indicating higher social functioning) had a stronger emotional bond with their service dog. It may be that children/adolescents with more verbal and nonverbal communication skills tend to interact with or talk to their service dog more, leading to higher caregiver perceptions of the child-dog bond. Indeed, research suggests that there are differences in how individuals with autism interact with animals depending on their social abilities and preferences. For example, an observational study of 16 children with autism interacting with a service dog for the first time found evidence of different subgroups: those that preferred more tactile contact with the service dog, those that preferred more vocal contact with the service dog, and those that relied on parental direction (62). Future research is needed to explore the relationship between autism phenotypes (e.g., eye contact preferences, sensory profiles, and social skills) and the development and maintenance of the child-service dog bond.

4.2 Caregiver outcomes

The second aim of this study was to assess the association of having a service dog on caregiver and family wellbeing. Contrary to our hypotheses, having a service dog in the home was not associated with caregiver-reported objective or subjective strain as a result of their child's emotional or behavioral problems, with small effects observed. Although qualitative studies have described how caregivers experience less stress from the sense of security provided by a service dog (20, 21, 24, 57), quantitative findings have been mixed. In fact, our findings mirror that of a larger cross-sectional study that compared families with and without an autism service dog on Caregiver Strain Questionnaire (CGSQ) scores (31). This discrepancy between qualitative and quantitative findings may be due to the nuances of caregiving burden. For example, qualitative data from the current study (57) as well as from other studies (19, 31, 58) suggest that service dogs can alleviate perceived stress for caregivers, but may also exacerbate or maintain current levels of caregiving pressure due to added dog-related needs. Future research will benefit from examining the impacts of service dogs on other more nuanced caregiving constructs such as caregiver satisfaction, which has been found to be sensitive to service dog placement in other caregiving populations (e.g., 63).

Caregivers who reported more perceived costs of the service dog (including financial costs, increased responsibility, and restrictions placed on the caregiver because of the dog) also reported higher caregiver strain. This finding mirrors a recent survey study of over 600 parents of children with autism which found a significant correlation between parents' perceived burden of having a pet and parents' self-reported stress (64). Indeed, caregivers of children with autism experience higher caregiver strain compared to caregivers of children with other disabilities (65). Importantly, the cross-sectional design of this study precludes inferences about causal relationships between caregiver strain and perceived costs of caring for the service dog. It is unknown whether strained caregivers perceive the service dog as more burdensome, or if caregivers that find the service dog to be burdensome develop more caregiving strain. Of note, the sample of caregivers in the current study were mostly White, educated, married, and of middle to high socioeconomic status. Given the evidence surrounding racial and ethnic disparities in autism (66), a more diverse sample is needed to gain a comprehensive understanding of the caregiving experience as it relates to service dogs. Future longitudinal research is also necessary to determine the role that financial, personal, and emotional costs of caring for a service dog may play in exacerbating or relieving caregiver strain, parental stress, and overall quality of life.

There was no significant effect of service dogs on caregiver sleep disturbance, including sleep quality, sleep depth, and restoration associated with sleep, with small effect sizes observed. This finding is particularly notable given that service dogs were associated with better *child* sleep behavior, including better sleep initiation and duration and less sleep anxiety/co-sleeping with the caregiver. Indeed, qualitative studies have found that caregivers of children with autism with a service dog in the home report improvements to their own sleep due to indirect effects of improvements in the child's sleep (20, 24). It is possible that the brief self-report measure chosen for this study (PROMIS Sleep Disturbance) did not capture these carry-over effects, or that the effect was too small to detect statistically. However, it is also important to note that caregivers in both groups had average levels of sleep disturbance (52.47 and 53.74) compared to the population average of 50, indicating that sleep disturbance was not common in this population and thus may not have been sensitive to change following service dog placement. Future research will benefit from pursuing more complex measurements of caregiver sleep, including sleep anxiety, child co-sleeping behavior, and objective measures of sleep quality and quantity.

Contrary to our hypothesis, there was no significant relationship between service dog presence and the severity of the negative impacts of the child's autism symptoms on the family's daily activities or relationships, with small effect sizes observed. Although some qualitative studies have suggested improvements to family functioning from autism service dogs (20, 21, 24), these studies primarily describe benefits to familial relationships and stress independent of the child's symptoms. Similarly, qualitative findings from the current study found that service dogs were described as a catalyst for improved family interactions by co-regulating with individual family members and providing a source of joy (57). Therefore, the measure chosen in the current study (PedsQL) may not have captured these nuanced impacts on family functioning, or the small sample size was not adequate to detect a small effect. Future studies may benefit from integrating more holistic family functioning scales that capture variability in the quality and quantity of familial interactions as well as longitudinal, larger-scale designs.

Interestingly, the higher the emotional closeness between a caregiver and the service dog, the more negative impacts the child's condition had on family activities and relationships. This may be due to the possibility that caregivers experiencing familial difficulties may be more likely to turn to the service dog as a source of support. This finding aligns with a previous study on caregivers of individuals with a mobility or medical service dog in which worse caregiver-reported psychosocial health was associated with higher emotional closeness with the service dog (67). This pattern has also been observed in studies of pet dogs in which a stronger human-animal bond has been associated with more psychological distress (68) and lower levels of positive experience (69). Future research should more closely examine the role of the caregiver-service dog bond, including its development and maintenance, as well as its implications for family functioning and caregiver wellbeing.

4.3 Limitations & future directions

This was a cross-sectional, single time point study and groups were not systematically matched on all demographic characteristics; we are unable to establish any causal relationships between variables. Longitudinal, randomized designs will be required to determine the causal effect of service dogs on child and caregiver outcomes. Second, caregiver-reported outcomes may have been influenced by self-reporting biases such as social desirability or recall bias. However, we could not integrate child self-report measures due to child/adolescent age and verbal ability differences. Future research will benefit from using objective measures of sleep, physiological biomarkers, observational methods, and more "real-time" data collection such as ecological momentary assessment to measure how service dogs impact child, caregiver, and familial functioning beyond self-report survey measures (70). Similarly, future studies integrating individualized assessments and objective methodologies (e.g., physiological biomarkers, wearable technology) will be needed to both characterize individual dog welfare (71) and to examine how these variables may impact child and/or caregiver outcomes.

Other limitations of this study pertain to sample characteristics. First, although all efforts were made to maximize sample size, the target population was limited in number, and sample size was relatively low. Specifically, the sample size had inadequate power to detect any small effects. Therefore, it may be that the study was underpowered to describe the subtle effects of service dog-related change in the constructs measured. Second, we relied on documentation of an autism diagnosis for children instead of conducting a standardized diagnostic assessment such as the Autism Diagnosis Observation Schedule (ADOS), which would have provided more accuracy. Child participants in this study were also heterogenous regarding co-occurring conditions and medications and treatments received. However, this is common in research with this population (72) and also represents a more ecologically valid sample that is representative of those who are placed with a service dog. Notably, our sample was a self-selected convenience sample that had actively sought out and applied for a service dog. Therefore, it is unclear how these results may generalize to children and adolescents with autism that are *not* amenable to a service dog. The sample is also not representative of the larger population of families of children with autism; caregivers were mostly White-identifying, non-Hispanic, highly educated (81% with a Bachelor's degree or higher) and of relatively high socioeconomic status (74% with an annual income of $75,000 or higher). Lastly, data collection for this study occurred during the coronavirus (COVID-19) pandemic, which may have influenced child, caregiver, and family outcomes.

4.4 Conclusion

In conclusion, this study adds to a limited but growing knowledge base on the effects of service dogs for children with autism and their caregivers. This exploratory cross-sectional study found that having a service dog was associated with better child sleep behaviors, suggesting that this should be a focus of increased research in this area. Specifically, research should further explore the effects of service dogs on child sleep quality, quantity, and disturbances using objective methods. We did not find significant associations between having a service dog and child social and emotional behavior, child peer relationships, caregiving burden, caregiver sleep, caregiver depressive symptoms, and family functioning, which were all observed with small effect sizes. It is possible that these null findings may reflect inherent challenges of naturalistic waitlist study designs or the application of standardized measurements to an individualized intervention in a heterogenous population with a small sample size. Larger prospective, randomized studies building on these initial findings will be necessary to fully evaluate the effects of service dogs on child and caregiver outcomes.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Purdue University Institutional Review Board (IRB Protocol #1906022320). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. The animal studies were approved by Purdue University Institutional Animal Care and Use Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was not obtained from the owners for the participation of their animals in this study because no interactions occurred between service dogs and the research team.

Author contributions

KR: Conceptualization, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. MR: Conceptualization, Methodology, Writing – review & editing. BK: Conceptualization, Methodology, Writing – review & editing. EM: Conceptualization, Methodology, Writing – review & editing. MO: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This project was funded by the Human-Animal Bond Research Institute (HABRI grant no. #HAB19-011), Nestlé Purina PetCare Global Resources, the Indiana Clinical and Translational Sciences Institute (CTSI), Pediatrics Project Developmental Team, and the Purdue University Clifford B. Kinley Trust. Nestlé Purina PetCare Global Resources was not involved in the study design, collection, analysis, interpretation of data, the writing of this article, or the decision to submit it for publication.

Acknowledgments

We are very grateful to Canine Companions for their support in conducting this research, especially Kerinne Levy, Brenda Kennedy, Sarah Leighton, Clark Pappas, and Laura Douglas. We also acknowledge the contributions of Katelyn Burgess, Harley Hill, Rhea Sparrow, and Morgan Uebelhor in assisting with data collection and participant communication. Finally, we gratefully thank all the caregivers, children, and service dogs for their participation in this study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 27 February 2024
DOI 10.3389/fpsyt.2024.1327380

OPEN ACCESS

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RECEIVED 24 October 2023
ACCEPTED 13 February 2024
PUBLISHED 27 February 2024

CITATION
Nieforth LO, Guerin NA, Stehli A, Schuck SEB, Yi K and O'Haire ME (2024) Observation of human-animal interaction for research (OHAIRE) behavior coding in a randomized control trial of children with attention-deficit hyperactivity disorder (ADHD) and a canine-assisted intervention.
Front. Psychiatry 15:1327380.
doi: 10.3389/fpsyt.2024.1327380

Observation of human-animal interaction for research (OHAIRE) behavior coding in a randomized control trial of children with attention-deficit hyperactivity disorder (ADHD) and a canine-assisted intervention

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Introduction: Diagnosed in about 10% of children in the United States, attention-deficit hyperactivity disorder (ADHD) is characterized by symptoms including inattention, hyperactivity, and impulsivity. Traditional interventions, such as pharmacological and psychological interventions, are often used in conjunction with integrative health options, such as animal-assisted interventions. The objective of this manuscript is to report behavior coding findings from a randomized control trial of children with ADHD.

Methods: As part of a larger randomized control trial focused on the efficacy of combining a canine-assisted intervention (live therapy dog or control stuffed dog) with cognitive behavioral therapy for children with ADHD, the current manuscript focuses on video-captured behavior observations (n = 35 children, approximately 322 minutes of data). Data were extracted and coded using the Observation of Human-Animal Interaction Research (OHAIRE) Coding System. Behavior codes are reported as summary scores for the following domains: animal social interaction and human social interaction (further separated into human-adult social interaction and human-peer social interaction). Repeated measures mixed models analyses were performed using SAS PROC GLIMMIX to evaluate group differences and change across the study period.

Results: There were no significant differences in how much children interacted with the live therapy dogs versus control stuffed dogs. With respect to human-to-human social interactions, children showed greater increases over time in human-directed social interactions in the presence of live therapy dogs compared to stuffed dogs ($p = .020$). Over the course of the 12-week intervention, children increased in interactions with both adults ($p = .006$) and their peers ($p = .014$); however, there were more increases over time in adult-directed social interactions in the live animal condition compared to the control stuffed animal condition ($p < 0.0001$).

10.3389/fpsyt.2024.1327380

Discussion & conclusions: Findings suggest changes in social interaction when participating in this canine-assisted intervention, specifically greater increases in human-to-human social interactions over time when a live therapy dog is present compared to a control stuffed dog. Children appear to engage relatively equally with both live and stuffed dogs; however, the impact of animals on human socialization differs based on if a live animal is present. Future studies should consider incorporating behavior coding analysis into studies of canine-assisted interventions to identify how human-animal interactions may be moderators or mechanisms for psychosocial outcomes.

KEYWORDS

animal-assisted intervention, therapy dog, attention-deficit hyperactivity disorder, complementary intervention, human-animal interaction

1 Introduction

Attention deficit hyperactivity disorder (ADHD) is characterized by inattention and hyperactivity or impulsivity that is maladaptive, inconsistent with development, and has been present for at least six months (1). Data from a 2016-2019 survey suggests that 9.8% of children and adolescents in the United States have received a diagnosis of ADHD in their lifetime (2). The Center for Disease Control and Prevention recommends both pharmacological treatment and behavior therapy for ADHD (3). Pharmacological treatment is the administration of stimulants, non-stimulants, or antidepressants to relieve ADHD symptoms (4). Though pharmacological treatment is effective for some individuals, an estimated 21% of children discontinue ADHD medication due to negative side effects and perceived ineffectiveness (5). Behavior therapy covers a variety of psychosocial interventions, including but not limited to behavioral interventions facilitated by parents and teachers, cognitive therapy or neurological training, and one-to-one counseling (6).

Multimodal interventions have been demonstrated to decrease psychopathology and increase quality of life in individuals with ADHD (7). Multimodal interventions can include combining multiple types of traditional interventions or combining traditional interventions with complementary and integrative health interventions. Families may choose to use complementary and integrative health interventions for a variety of reasons (e.g., due to comorbid disorders, desire to try anything, or fear of adverse events of pharmacological interventions). The percentage of families that have tried complementary and integrative health options for ADHD treatment ranges from 5-64%, with the large range due to the inclusion of dietary changes as a complementary intervention option (8, 9). Common types of complementary interventions include vitamins and dietary supplements, herbal medicines, sensory integration, art, relaxation, neurofeedback, and massage (10).

Another type of complementary intervention, that is increasingly common, is an animal-assisted intervention (AAI). AAI is the partnership with an animal in any part of the intervention process and may include animal-assisted therapy (AAT), animal-assisted activities (AAA), animal-assisted education (AAE) or assistance animals (11). Anecdotally, individuals find these complementary options helpful, but there is still little clinical evidence, and the evaluation of the safety of the intervention is weak (12). To date, there have been only five randomized controlled studies conducted that have investigated the interaction between therapy animals and individuals with ADHD (13–17). Only two of these randomized controlled studies examine canine-assisted interventions while the others focused on equine-assisted interventions and farm animal experiences.

One randomized control study was a four-year study on public school special education students with ADHD (n = 26), autism spectrum disorder (ASD), and emotional disability (ED) (13). Children were bussed to a farm once a week for a two-hour session where they worked to gain a collection of skills to handle the different types of farm animals independently. During the first year of the study, the classroom teacher and farm teacher each evaluated the children on the Achenbach Teacher Rating System twice throughout the year. For the next three years, the teachers switched to the Behavior Assessment System for Children Teacher Rating System (BASC TRS). Results suggest that all BASC TRS factor scores and problem scores were lower in the farm program compared to the classroom, but the adaptability scores had not changed.

A second randomized study looked at physiological reactions to dogs in 17 children with ADHD (17). Systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate were measured both during the control session (no dog present) and the experimental session (dog present- children given no instruction regarding interaction with dog). Teachers also rated the children's behavior after each session on a five-point scale. Results demonstrate that there were no significant changes in teacher ratings. DBP significantly increased while children held the dog, SBP significantly increased following holding the dog, and heart rate significantly decreased

following holding the dog. Findings suggest that the increase in blood pressure was interpreted as a response to the positive stimuli and that the decrease in heart rate was potentially an orienting behavior.

A third study was a randomized block design study that examined effects of hippotherapy (intervention group) versus a physical rehabilitation activity program (control group) on brain function of individuals with ADHD (14). Measures included physical characteristics, muscular and cardiorespiratory fitness, functional MRI, and brain-derived neurotrophic factor. Findings suggest that participation in hippotherapy significantly decreased body fat and increased brain-derived neurotrophic factor (14).

A fourth study, compared hippotherapy to pharmacotherapy for the treatment of ADHD (15). Measures included ADHD Rating Scale, Child Behavior Checklist, Self-esteem Scale, Pediatric Quality of Life Inventory, Developmental Coordination Disorder Questionnaire, Clinical Global Impressions-Severity and Electroencephalography. Results suggest improvement in ADHD symptoms and Clinical Global Impressions-Severity in both groups. The hippotherapy group also demonstrated improved attention, impulsivity/hyperactivity, and quality of life.

A fifth study, of particular interest as the parent study of the current project, a combination of cognitive behavioral therapy (CBT) and canine-assisted intervention (CAI) was investigated (16, 18, 19). In this study, 88 children with ADHD participated either in the control group (CBT without CAI) or experimental group (CBT and CAI). Parents completed the ADHD – Rating Scale – Fourth Edition, Home, and School Version, the Social Skills Improvement System – Rating Scales, Parent Form and Social Competence Inventory (18). Total ADHD symptoms, inattention and social skills had significant main effects related to group (16). There were also significant interaction effects (group x time) for problem behaviors and social initiation (16). Additionally, self-reported behavioral conduct, scholastic and social competence were significantly higher in the CAI group post-treatment than they were pre-treatment with no pre- to post- treatment changes in the non-CAI group indicating benefits to the intervention (19). The manuscript cited here consists of the intervention primary outcomes of the parent study. The current project is an extension of these findings, looking specifically at identifying if behaviors and interactions were different within the sessions themselves.

Taken together, these five studies align with one another in that they all suggest preliminary benefits for animal-assisted interventions for individuals with ADHD. Each study incorporates a different methodology, together suggesting both psychosocial and physiological improvements upon participation in an animal-assisted intervention. Though these five studies set the foundation for rigorous, empirical research incorporating multiple methodologies, additional forms of measurement, beyond surveys and physiological measures, are necessary to continue to build the evidence-base and understand the mechanisms occurring in the intervention. Specifically, there is a gap in the literature regarding the understanding of what is actually occurring between the children, the animals and the other humans present during the interaction. This is important to understand mechanistically how the intervention works. One methodology that has yet to be used in the examination of animal-assisted interventions for ADHD, yet will directly address this gap, is behavior coding. Behavior coding enables direct observation of changes in behavior during an intervention, providing an objective, empirical perspective of the intervention (20). The Observation of Human-Animal Interaction for Research (OHAIRE) Coding System is a standardized, validated behavior coding tool developed to measure the social interaction behaviors of participants, peers, and animals during both animal-assisted interventions and control conditions (21). The OHAIRE Coding System has demonstrated a convergence between OHAIRE recorded social behaviors and social skills assessed by the Social Skills Rating System (21). This convergence makes this particular coding system well-suited for this study as findings from the parent study suggest changes based on the Social Skills Rating System (19, 22). Previous studies incorporating behavior coding have been successful in objectively analyzing social behaviors of children with ADHD but have yet to incorporate coding of interactions between humans and animals (23, 24). Coding the social interactions between humans and animals is particularly relevant as a potential mechanism for social skill development in canine-assisted interventions (18, 22).

The purpose of the current manuscript is to report on the behavior coding of video data collected as part of the Schuck et al., 2018 randomized control trial. To date, this is the first manuscript to report on video recorded behavior coding in a randomized control trial of children with ADHD and a canine-assisted intervention. The hypothesis was that the presence of an animal within a canine-assisted intervention would lead to an increase in social behaviors both over time and between groups.

2 Methods

2.1 Study design

This manuscript is part of the Project Positive Assertive Cooperative Kids (P.A.C.K.) randomized control trial focused on examining a canine-assisted intervention combined with cognitive-behavioral therapy for children with ADHD. At the time of funding (2010), the parent institution did not approve of the trial being registered as a clinical trial as it had no medical devices or medicines being studied. Instead, the institution deemed it a randomized controlled trial. This study was approved by two University Institutional Review Boards (UC Irvine Protocol # 2010-7679, Purdue University Protocol # 1410015340) and received an exemption from Purdue Institutional Animal Care and Use Committee as the researchers did not have any interaction with the animals.

Eligibility for participation was determined from a screening procedure which included a parent-reported family medical and psychosocial history questionnaire, researcher administered Kaufman-Schedule for Affective Disorders and Schizophrenia for School-Age Children: Present and Lifetime Version, researcher administered Wechsler Abbreviated Scale of Intelligence, Second Edition and a semi-structured clinical-administered interview with parents and children based on the Diagnostic and Statistical Manual of Mental Disorders for psychiatric disorders (18). To be included

in the study, participants had to have a primary diagnosis of ADHD, Combined subtype, be 6-9 years old, and have an estimated full scale IQ score of 80 or above and the ability to complete all screening measures (18). Participants were excluded if they were currently using medication for ADHD, had a diagnosis of a pervasive developmental disorder/autism, depression, anxiety, or epilepsy, or a history of animal cruelty (18). After participants were screened and eligible, informed consent was collected.

Participants completed a variety of clinical survey measures immediately prior to the study, during the study, and immediately following the study and 6-weeks after the 12-week intervention. Parents also completed surveys regarding symptom severity, social skills, and problem behaviors at the same timepoints. Clinical survey measures and associated outcomes can be found in (16) and (19).

Participants were randomly assigned to the canine assisted intervention group (registered live therapy dog) or the control group (toy stuffed dog). In addition to randomization, half of participants were placed in a waitlist condition to control for the possible influence of time and child development (18). All participants participated in a cognitive behavioral therapy intervention curriculum. The intervention curriculum, P.A.C.K., included components of the University of California, Irvine Child Development Center School-based Social Skills model, the Kids Interaction with Dogs Safely program and the Intermountain Therapy Animals' Reading Education Assistance Dogs Program. Example activities included writing in journals, reading, and learning about different coping mechanisms.

Children participated in the study for 12 weeks for a total of 23 sessions. Three canines were part of the canine-intervention group, each partnered with a human handler who facilitated the interactions. There was a 1:2 ratio of dog or stuffed dog to children. Sessions were completed in large groups with multiple dogs available per session. In addition to the outcomes collected via screening interviews and study surveys, all sessions were video recorded to capture behavior observation data. The video-recording component of the study was an ancillary component that was added after the start of the trial. All participants were subject to the same randomization procedure, but since the recordings did not start at the beginning of the trial, fewer participants were included in this component of the study. The current manuscript explores the video-captured behavior observation components of the study.

2.2 OHAIRE coding procedure

Five sessions (sessions 1,7,12,18, and 23) were video recorded to capture behavior observation data. These sessions were selected to maximize the total number of participants present during the video recorded sessions and to represent sessions throughout the entirety of the study. Data extraction replicated the OHAIRE Coding System (25) where 10-minute video segments were divided into thirds and 1-minute segments were randomly selected from each of those segments. Therefore, three minutes from each of the selected sessions were randomly selected for behavioral coding for each participant. The OHAIRE coding system was specifically designed for human-animal interaction research projects and demonstrates good reliability and validity (21).

Two research assistants coded the behavior of children with ADHD and their peers. Coders were blinded to the aims and hypotheses of the study, but due to the nature of the study (presence of the dog vs. no dog) raters were not blind to the condition. Coder 1 coded 98% of the data (the 3 minutes that were not coded were dropped from the analysis) and coder 2 coded 23% of the data to establish interrater reliability. Interrater reliability was calculated using Cohen's Kappa. The overall agreement among raters was 86.5% ($k = .865$, $p<.001$). Interrater reliability was also calculated for specific categories of interactions ($k = .736$, $p<.001$), facial emotional displays ($k = .756$, $p<0.001$), verbal valence ($k = 0.98$, $p<0.001$), social communication ($k = .655$, $p<0.001$), and problem behaviors ($k = .894$, $p<0.001$).

Across the study period's five assessment sessions, a total of 322 minutes were selected for coding (intervention group: 173 minutes, control group: 149 minutes). The average per child was 9.2 minutes (SD: 2.66, Range: 3-13 minutes). Following the OHAIRE Coding System, coders rated the absence or presence of a behavior in 10 second intervals. The score for each behavior code is the number of 10-second intervals it was present within a minute (i.e., a count ranging from 0-6). Summary scores were created for the following domains: Animal Social Interaction and Human Social Interaction (further separated into Human-Adult Social Interaction and Human-Peer Social Interaction). Each summary score was the sum of the six "interactions" items towards the relevant target, resulting in variables with a possible range of 0-36.

2.3 Analysis

Demographics and baseline psychosocial measures of each group (dog vs. stuffed dog) were compared using independent sample t-tests for continuous measures and Fisher's exact tests for categorical variables. Descriptive statistics, (i.e., means, variance, frequency distribution/quantiles) of each outcome measure were reviewed both across and within the sessions.

Repeated measures mixed models analyses were performed to evaluate group differences (dog versus stuffed dog), change across the study period and the group by time interaction. Utilizing PROC GLIMMIX in SAS, a random effects Poisson model with a loglink function was specified due to the count data. If there was overdispersion, a negative binomial regression model was implemented instead. The mixed model approach allowed for within subject intercorrelation due to repeated measures to be accounted for, and all participants to be included regardless of missed sessions, Individual participants contributed up to 3 ratings per session. Sensitivity analyses were performed to determine there were no significant biases related to those with more ratings in a session or with missing data for a given session.

3 Results

Final analysis included observational data from n = 35 participants (Table 1). There were no significant effects for any sociodemographic characteristics across groups (all p's > 0.52). The intervention (CAI) and control (stuffed dog) groups did not differ by sex (p = 0.73), gender (p > 0.999), age (p = 0.68), grade (p = 0.64), ethnicity (p = 0.72), or race (p = 0.58). Additionally, scores from the ADHD-Rating Scale demonstrated no significant difference in ADHD symptom severity between groups (p =0.52-0.99).

Both pre/post models and summary models including all session assessment points were conducted. Both follow the same patterns, so the summary models inclusive of all assessment points are presented here (Table 2).

The Animal Social Interaction summary model found nonsignificant effects across conditions (p = 0.496), sessions (p = 0.873) and within the group x time interaction (p = 0.416). The Human Social Interaction summary model found a nonsignificant session effect (p = 0.667), a nonsignificant condition effect (p = 0.376), and a significant group x time interaction (p = 0.020). Given the significant interaction effect within the human interaction model, further exploration was conducted to examine human-adult versus human-peer interactions. The Human-Adult Social Interaction model found a nonsignificant condition effect (p = 0.065), but a significant session effect (p = 0.006) and a significant group x time interaction effect (p < 0.0001). The Human-Peer Social Interaction model found a nonsignificant condition effect (p = 0.348), a significant session effect (p = 0.014) and a nonsignificant group x time interaction effect (p = 0.767).

Findings suggest a different pattern of Human Social Interaction over time across the treatment versus control group. Specifically, human-directed social interaction increases more over time when a live dog is present compared to a stuffed dog. With respect to social interactions with children and adults, both increase over the course of the intervention program. The significant interaction in Adult Social Interaction indicates that the change over time differs between groups (e.g., potentially that adult interactions increase more over time in the live dog group).

4 Discussion

To our knowledge, this manuscript is the first to employ behavior coding to assess the interactions of children with ADHD and animals during a structured AAI. Although interactions with animals are similar in both groups (live and stuffed animal dogs), results show change in participant interactions with humans, most saliently with adults. Individuals diagnosed with ADHD may have difficulties in social interactions (26). Previous human-animal interaction research suggests that animals may be a social facilitator or an external focus of attention that may have positive impacts on social interactions (27, 28). These findings align with the quantitative survey findings from this same randomized controlled trial study, showing that structured canine-assisted interventions not only increase self-reported behavioral conduct, scholastic competence and social competence, but may also promote social interaction for children with ADHD (16). Given that both adult interaction and peer interaction increased over the course of the intervention, yet the change over time differed between these, practitioners should consider how opportunities to interact socially are intentionally integrated into canine-assisted interventions or animal-assisted interventions more broadly. Highlighting opportunities to engage with peers and adults or incorporating the guidance of an adult into peer-to-peer interaction (or vice versa) may identify ways to refine the intervention focusing on the potential benefits of the intervention in providing increased interactions between participants and other individuals present, whether children or adults.

Findings also highlighted that the children in the current study socially interacted in a similar format and frequency with both live and stuffed dogs. It may be that the theme of dogs or representation of dogs enables similar social interaction patterns as live dogs. Multiple studies have compared live animals to stuffed animals in the context of AAI and outcomes are mixed. For example, research examining the activation brain activity suggests that both interaction with a live dog and a stuffed animal dog increased brain activity, but the live dog stimulated more activity than the stuffed dog (29). Another study suggests that interaction with a robot dog and a live dog can be similar regarding the effects on mood, but different when examined on a deeper cognitive attribution level (30). Other research suggests differences in live dog versus stuffed dog regarding children laughing more, keeping their gaze on the dog, and increased social interactions with the live dog in comparison to the stuffed dog or control toy (31). Considering our findings within this larger body of work suggests that there are multiple mechanisms affecting these interactions. Our findings suggest that the frequency of interaction with the source (live or stuffed dog) may not be driving the changes in outcome differences between live and stuffed dogs because those frequencies are similar between groups. There is potentially another mechanism at play, highlighting that there is something else about a live animal that drives the changes in outcomes, beyond the frequency of social interactions. Additional studies are needed to identify this mechanism or group of mechanisms.

A few limitations should be considered regarding the results presented. First, this study included only one population of children with ADHD and had a small sample size. Second, only select sessions within the intervention were video recorded. Given the manualized nature of the intervention, this may have affected the behaviors that appeared in the dataset. For example, the structured intervention protocol directs adults and children to engage in certain activities (e.g., sitting and listening) rather than free, open-ended interactions in many cases. This would limit the availability and variability of some social behaviors (e.g., talking and playing) during specific sessions. Although these structured formats were equivalent across the treatment and control groups, they may have limited the time available to observe behavioral variation across participants. Given that the OHAIRE Coding tool was designed to assess unstructured interactions, results may have varied if the sessions included more opportunities to help the animal or touch the animal based upon the protocol. Similarly, if peer-interaction is a focus of the program, creating opportunities to help peers within the canine-assisted intervention may have altered

10.3389/fpsyt.2024.1327380

TABLE 1 Demographics.

Characteristic	Dog, N = 18 (51%)	Control, N = 17 (49%)	Overall, N = 35	p-value[1]
Sex, n (%)				0.725
F	5 (28%)	6 (35%)	11 (31%)	
M	13 (72%)	11 (65%)	24 (69%)	
Gender, n (%)				> 0.999
Female	5 (28%)	5 (31%)	10 (29%)	
Male	13 (72%)	11 (69%)	24 (71%)	
Unknown	0	1	1	
Age, n (%)				0.675
6	0 (0%)	1 (5.9%)	1 (2.9%)	
7	11 (61%)	8 (47%)	19 (54%)	
8	5 (28%)	5 (29%)	10 (29%)	
9	2 (11%)	3 (18%)	5 (14%)	
Grade, n (%)				0.644
1	4 (24%)	5 (29%)	9 (26%)	
2	8 (47%)	5 (29%)	13 (38%)	
3	3 (18%)	6 (35%)	9 (26%)	
4	2 (12%)	1 (5.9%)	3 (8.8%)	
Unknown	1	0	1	
Ethnicity, n (%)				0.721
Hispanic/Latino	7 (41%)	5 (31%)	12 (36%)	
Non-Hispanic	10 (59%)	10 (62%)	20 (61%)	
Decline to Answer	0 (0%)	1 (7%)	1 (3%)	
Unknown	1	1	2	
Race, n (%)				0.582
Alaska Native	0 (0%)	0 (0%)	0 (0%)	
Asian	2 (12%)	3 (18%)	5 (15%)	
African American	0 (0%)	0 (0%)	0 (0%)	
Pacific Islander/Native Hawaiian	0 (0%)	0 (0%)	0 (0%)	
Caucasian	10 (59%)	9 (53%)	19 (56%)	
Multiple	5 (29%)	3 (18%)	8 (24%)	
Other	0 (0%)	2 (12%)	2 (5.9%)	
Unknown	1	0	1	
ADHD Symptoms Baseline, Mean (SD)	13.33 (3.65)	13.06 (3.59)	13.21 (3.57)	0.808
Unknown	0	1	1	
Hyperactive Impulsive Symptoms Baseline, Mean (SD)	6.06 (2.69)	6.12 (2.28)	6.09 (2.47)	0.875
Unknown	0	1	1	
Inattention Symptoms Baseline, Mean (SD)	7.28 (2.19)	6.94 (2.21)	7.12 (2.17)	0.523
Unknown	0	1	1	
ADHD Total Score Baseline, Mean (SD)	36.17 (7.73)	34.69 (6.95)	35.47 (7.30)	0.545

(Continued)

TABLE 1 Continued

Characteristic	Dog, N = 18 (51%)	Control, N = 17 (49%)	Overall, N = 35	p-value[1]
Unknown	0	1	1	
Hyperactive Impulsive Frequency Baseline, Mean (SD)	16.83 (4.96)	16.19 (4.25)	16.53 (4.58)	0.665
Unknown	0	1	1	
Inattention Frequency Baseline, Mean (SD)	19.33 (4.45)	18.50 (4.35)	18.94 (4.36)	0.579
Unknown	0	1	1	
ODD Symptoms Baseline, Mean (SD)	3.28 (2.97)	3.25 (2.89)	3.26 (2.88)	0.986
Unknown	0	1	1	
ODD Total Score Baseline, Mean (SD)	11.11 (6.21)	10.44 (6.91)	10.79 (6.46)	0.653
Unknown	0	1	1	

[1]Fisher's exact test; Wilcoxon rank sum test.

the behaviors observed. Future studies should consider adapting the OHAIRE Coding tool to incorporate overarching program goals and to modify it to the specific animal species and programmatic goals of interest. Tailoring the structure to the needs of the animal (i.e., teaching participants to recognize and address the needs of the animal within the intervention) may positively promote the welfare of the animals included in the intervention.

5 Conclusion

The purpose of the current manuscript was to report on findings from video-recorded behavior coding in a randomized control trial of children with ADHD and a canine-assisted intervention (16). The hypothesis was that the presence of an animal within a canine-assisted intervention would lead to an increase in social behaviors. Participants demonstrated greater increases in human-directed social interaction over time in the live therapy dog condition, compared to the control stuffed dog condition. While interactions with peers and adults increased over time in both conditions, changes were more salient for adult interactions in the live therapy dog condition. Interestingly, there were no significant findings regarding differences in the interaction with the animals between groups, suggesting no differences in the frequency of interaction with a live dog versus a stuffed dog. Results are preliminary but suggest potential benefits of canine-assisted interventions for social interaction patterns in children with ADHD.

TABLE 2 Model results: summary scores.

	F Value	Pr > F
Animal Interaction		
Condition	0.47	0.496
Session	0.03	0.873
Session*Condition	0.66	0.416
Human Adult Interaction		
Condition	3.44	0.065
Session	8.81	0.006
Session*Condition	16.93	< 0.001
Human Peer Interaction		
Condition	0.88	0.348
Session	6.73	0.014
Session*Condition	0.09	0.767
Human Total Interaction		
Condition	0.79	0.376
Session	0.19	0.667
Session*Condition	5.53	0.020

The * indicates the interaction.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Purdue University Institutional Review Board (#1410015340) and UC Irvine Institutional Review Board (# 2010-7679). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

LN: Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. NG: Investigation, Writing – original draft, Writing – review & editing. AS: Formal analysis, Methodology, Software, Writing – review & editing. SS:

Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing. KY: Data curation, Writing – review & editing. MO: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was supported by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) and Mars-WALTHAM® Grant R01H066593. This research also was supported by funding from the National Center for Research Resources and the National Center for Advancing Translational Sciences, National Institutes of Health (NIH), through Grant UL1 TR000153, as well as funding from the NIH Loan Repayment Program (L60MD002127). This content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health (NIH).

Conflict of interest

NG was employed by Implicity.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 03 April 2024
DOI 10.3389/fpsyt.2024.1373525

OPEN ACCESS

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RECEIVED 19 January 2024
ACCEPTED 05 March 2024
PUBLISHED 03 April 2024

CITATION
McDonald SE, Kogan LR, Nageotte NL, Currin-McCulloch J and Dickler-Mann R (2024) Zoo professionals and volunteers in the U.S: experiences and prevalence of burnout, mental health, and animal loss. *Front. Psychiatry* 15:1373525. doi: 10.3389/fpsyt.2024.1373525

Zoo professionals and volunteers in the U.S: experiences and prevalence of burnout, mental health, and animal loss

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Introduction: Burnout and mental health among animal care and health professionals (ACHPs) has received increasing attention in recent years. Despite rapid growth of research in this area, the wellbeing of individuals who work and/or volunteer in zoo settings has received minimal attention.

Method: An anonymous online survey was created to evaluate zoo staff and volunteers' experiences of animal-related loss, rates of professional fulfillment and burnout, mental health, perceived organizational support, and resilience. Participants included 1695 zoo professionals (72% ACHPs, 20% other staff) and volunteers (7%) who were recruited through relevant professional listservs and online platforms, and flyers on zoo grounds.

Results: ACHPs reported higher levels of anxiety, depression, and burnout and lower levels of professional fulfillment than other zoo staff and volunteers. The most common animal-related losses experienced by ACHPs in the past year were unexpected death (80%) and anticipated loss (74%), with more than half of these losses occurring within the past 3 months. ACHPs' reported bond with animals under their care was positively associated with depression and anxiety. Having a formal ritual or process following the death of an animal was positively associated with job fulfillment and perceived organizational support and negatively associated with depression and burnout—yet only 17% of participants in our sample indicated that their zoo had such a process or ritual.

Discussion: Our findings suggest that many ACHPs are struggling with burnout, anxiety, depression, and low rates of professional fulfilment and perceived organizational support. We recommend that zoos develop organizational plans that foster a culture which normalizes and validates grief/loss experiences and is proactive in responding to animal loss, related trauma, and other occupational stressors. The results of this research demonstrate the need for systemic changes within the zoo industry, for the betterment and welfare of both humans and the animals under their care.

KEYWORDS

zoos, loss, grief, mental health, burnout, resilience, animal care, animal health

1 Introduction

In recent years, the issue of burnout and mental health among animal care and health professionals (ACHPs) has received increasing attention in the fields of veterinary science and human-animal interaction (1–7). ACHPs is a broad term referring to employees or volunteers who look after animals, with roles including, but not limited to, veterinarians, veterinary nurses, animal attendants, wildlife carers, foster carers, zookeepers, and administrative workers (3). There is growing evidence that ACHPs have higher rates of stress-related mental health problems than the general population (3). When ACHP well-being is not adequately addressed, exposure to occupational stressors (e.g., animal injury, illness, suffering, euthanasia, death) on a routine basis can lead to compassion fatigue, burnout, and mental health issues (5, 8). Despite rapid growth in this area of research, individuals who work and/or volunteer in zoo settings have not been adequately evaluated. The current study addresses this gap by examining experiences of animal-related loss, rates of professional fulfillment and burnout, mental health, perceived organizational support, and resilience in a sample of zoo professionals and volunteers in the United States.

1.1 Burnout and mental health

The impacts of occupational stressors such as depression, burnout, and grief and loss, as well as the circumstances contributing to these experiences, are not well understood in the context of contemporary zoos. However, occupational stressors and their impacts are well-documented in similar professions that center on animal care and husbandry, such as general veterinary practice (9–12), animal laboratory settings (13–15), and animal shelters (16–18). Multiple studies have found high rates of PTSD symptoms, psychological distress, burnout, and grief among ACHPs across these settings (3, 6, 16, 19–28). For example, a recent study of animal shelter staff demonstrated that these employees often suffer from secondary traumatic stress (10); moreover, the chance that U.S. animal shelter employees will have posttraumatic stress disorder is five times higher compared to the national average (16). Similarly, studies suggest that veterinary professionals experience high rates of compassion fatigue, secondary traumatic stress, burnout, anxiety, depression, and suicide ideation (6, 23, 29–36).

Occupational stressors that contribute to these outcomes include emotional and moral challenges such as exposure to animal suffering, injury, and death (8). Other stressors include difficult work schedules, financial challenges (educational debt, low-pay), management dissatisfaction, excessive workloads, role ambiguity, physically demanding and exhausting job duties, and the cumulative exposures to highly stressful work events (7, 21, 31, 37). ACHPs and allied professionals in zoo settings experience similar stressors to these populations [e.g., exposure to euthanasia. animal illness, animal transfers; (38, 39)] and like ACHPs in other settings, often become attached to animals in their care (39). Marino (40) examined experiences of burnout in a convenience sample of 616 people who currently or previously worked at zoos and aquariums. This study found that 91% of the sample reported they experienced burnout while working at a zoo or aquarium, and 60% stated they left a position because of burnout. They found that participants who identified as Black, Indigenous, and/or people of color were more likely than those who identified as white to leave their positions because of burnout. Additionally, participants who experienced harassment and discrimination in their workplace were also significantly more likely to experience burnout and leave their positions because of it. Thus, there is an urgent need to better understand rates of burnout and mental health among these professionals. Further, understanding the types of animal losses zoo staff and volunteers experience (e.g., anticipated loss, unexpected loss, animal transfers), and how these types of losses are associated with burnout and wellbeing, could assist the zoo industry in understanding how to best support their staff and volunteers in coping with typical job stressors and guide evidence-based practices to promote mental health and wellbeing in this industry.

1.2 Factors that may facilitate wellbeing

In addition to emotional and moral challenges, it is also important to focus research attention on understanding positive aspects of work in zoo settings and to identify how factors such as individual resilience, organizational support, and professional fulfillment are associated with zoo staff and volunteers' wellbeing and ability to adaptively cope with typical occupational stressors. Personal resilience is a term often used to refer to an individual's ability to adjust to adversity or setbacks, retain a sense of control over their environment, and continue to persist in a healthy and adaptive manner (41). Resilience is often negatively associated with burnout in health professionals (42, 43), and prior work highlights the importance of an individual's personal resilience in the context of stressful occupations, including animal care work (44, 45). In addition, organizational support has also been identified as an important factor that may influence the wellbeing of ACHPs and individuals who work in other stressful professions (8, 42, 46–48). Indeed, a recent study of Australian ACHPs found that perceived organizational support accounted for approximately 17% of the variance in burnout (8). Moreover, perceived organizational support in this sample was found to be inversely related to anxiety, depression, PTSD symptoms, grief, and stress. Relatedly, there is some evidence that professional fulfillment may be associated with higher levels of well-being and reduce feelings of burnout among some groups of ACHPs (although emerging evidence suggests low rates of professional fulfillment among some ACHPs [i.e., veterinary technicians (11), shelter veterinarians (49)]). For example, Wallace (50) found that veterinarians in clinical practice who felt their work was fulfilling and meaningful reported higher levels of wellbeing.

1.3 Zoo volunteers

There has been minimal research on these topics for zoo professionals but even less for those who volunteer within zoos.

Many organizations in the U.S., particularly non-profits, rely heavily on volunteers. This is especially true for zoos across the United States, which frequently rely on volunteers for animal care, education, conservation efforts, and other programming (51, 52). Zoo volunteers may experience similar stressors and outcomes as paid employees; moreover, factors that support their wellbeing may be comparable to or different from paid staff (52). Research on volunteers in other non-profit settings centered on animal care and rehabilitation suggests that volunteers experience compassion fatigue (18, 53). Additionally, there is some evidence that rates of compassion fatigue (comprising burnout and secondary traumatic stress) are comparable between paid staff and volunteers in animal shelter settings (54). Given links between stress and turnover [e.g., 25, 55)], it is important for the zoo industry to invest in identifying factors associated with zoo volunteers' wellbeing.

1.4 Current study

Understanding rates and types of animal loss, burnout, and mental health among zoo professionals and volunteers can help guide the zoo industry in efforts to better support and care for the individuals who carry out their mission. Additionally, understanding zoo professionals' perceptions of professional fulfillment, organizational support, and personal resilience has implications for informing strategies to support positive coping and wellbeing among people who work and volunteer in this industry. To this end, the current study was designed to survey current zoo professionals and volunteers working at AZA (Association of Zoos and Aquariums) accredited institutions within the United States. Specifically, we aimed to examine rates of animal loss, professional fulfillment, burnout, anxiety, depression, resiliency and perceived organizational support among zoo professionals and volunteers, and differences in these rates between ACHPs, other zoo staff, and volunteers. We also aimed to identify predictors of job fulfillment, burnout, depression, anxiety, and perceived organizational support among ACHPs, adjusting for the potential confounding effects of demographic factors. This study was exploratory and, therefore, there were no specific hypotheses.

2 Materials and method

2.1 Study design

An anonymous online survey was created to evaluate zoo staff and volunteers' experiences of animal-related loss and grief in the workplace. Related constructs including professional fulfillment and burnout, organizational support, anxiety and depression, and resilience were also assessed. The survey was created and tested by researchers at Denver Zoological Foundation (Denver Zoo) and Colorado State University after seeking input from several members of the Denver Zoo community. Recruitment and data collection took place from July 26, 2023, through October 15, 2023. Surveys were completed electronically using the Alchemer survey platform and took approximately 15 minutes to complete. The survey was only offered in English. Following completion of the survey, participants had the option of clicking on an external link to an electronic form where they could provide their name and contact information for the chance to enter a drawing for a catered lunch for themselves and their colleagues ($250). This data was stored separately from the survey data.

We used multiple platforms to recruit our participants. First, information about the study (including the survey link and study flyer) was posted to the AZA website on the AZA network. Specifically, we posted to the following forums: Animal Ambassadors, Continuous Improvement in Zoos and Aquariums, Curators, Education, Research and Technology, Social Science Research and Evaluation Scientific Advisory Group, Volunteer and Intern Engagement, and Volunteer/Docents. An executive team member at Denver Zoo posted the same information to the following AZA groups: Amphibians, Animal Health, Animal Management, Animal Welfare, Avian Interest Group, Chelonians, Crocodilians, General Curators, Lizards, Snakes, and Ungulates. Messages posted to these forums provided the survey link and study flyer and invited forum participants to: a) participate in the survey and/or b) contact the first author if they were interested in sharing this study information with staff, volunteers, and/or their institutional leadership.

Following these recruitment efforts, staff at other zoos (see acknowledgements section) contacted the first author and shared the survey with members of their staff. In addition to the AZA network, we recruited participants through several listservs (e.g., American Association of Zookeepers) and other zoo-related social media pages on Facebook, Instagram and LinkedIn (The Zoo Scientist, Growing Resilience in Zoo and Aquarium Professionals; Association of Minority Zoo & Aquarium Professionals). Study flyers were also posted at the 2023 Annual AZA Conference.

2.2 Participants

A total of 2,492 respondents completed the survey screening questions. Participants were eligible to participate in the study if they were currently working or volunteering (and had for at least 6 months) at an AZA accredited zoo within the U.S. A total of 329 responses were disqualified through the screening process and 468 responses were disqualified because they provided only partial responses, leaving a final sample size of 1695 for analysis. The average age of participants in the sample was 37 years (*SD*= 11.6). Study participants predominately identified as female, feminine, or woman (79%) and white (91%) with a Bachelor's degree (1115, 67%). Twenty percent (N = 334) identified as LGBTQ+, with a majority of these individuals identifying as Bisexual (144, 43%) or Queer (62, 19%). Participant demographics are provided in Tables 1–3.

2.3 Measures

2.3.1 Professional fulfillment and burnout

The Stanford Professional Fulfillment Index [PFI; (56)] was used to assess self-reported professional fulfillment and professional

TABLE 1 Participants' reported work or volunteer hours and length of time working in a zoo setting.

Role	ACHP (n = 1252)	Other (n= 332)	Volunteer (n = 111)
Work Schedule	N (%)	N (%)	N (%)
Full Time	1195 (95)	274 (83)	–
Part Time/Variable Part-Time	50 (4)	47 (14)	–
Seasonal	7 (1)	11 (3)	–
Hours volunteered per month	**–**	**–**	**17.1 (SD = 13.7)**
Years working in zoo setting	**N (%)**	**N (%)**	**N (%)**
Less than one year	5 (<1)	13 (4)	3 (3)
1-4 years	174 (14)	100 (30)	29 (26)
5-9 years	359 (29)	101 (30)	27 (24)
10-19 years	428 (34)	77 (23)	32 (29)
20+ years	286 (23)	41 (12)	20 (18)

TABLE 2 Participants' reported demographics.

Role	ACHP (n = 1252)	Other (n= 332)	Volunteer (n = 111)
Age	35.6 (SD = 9.3)	36.9 (SD = 11.0)	57.0 (SD = 17.9)
Education level	N (%)	N (%)	N (%)
Less than High School	1 (<1)	0	3 (3)
High School or GED	38 (3)	26 (8)	6 (5)
Associate's degree (2 year)	111 (9)	33 (10)	13 (12)
Bachelor's degree (4 year)	906 (72)	170 (51)	39 (35)
Master's degree	123 (10)	88 (27)	42 (38)
Doctoral degree	52 (4)	9 (3)	6 (5)
Prefer not to say	21 (2)	6 (2)	2 (2)
Ethnicity	**N (%)**	**N (%)**	**N (%)**
Hispanic or Latino	75 (6)	23 (7)	2 (2)
Not Hispanic or Latino	1115 (89)	285 (86)	94 (85)
Prefer not to say	62 (5)	24 (7)	15 (14)
Race*	**N (%)**	**N (%)**	**N (%)**
American Indian or Alaska Native	16 (1)	9 (3)	2 (2)
Asian	27 (2)	9 (3)	1 (1)
Black or African American	24 (2)	13 (4)	0
Native Hawaiian or Other Pacific Islander	8 (1)	1 (<1)	0
White	1155 (92)	285 (86)	98 (88)
Prefer to self-describe	14 (1)	8 (2)	2 (2)
Prefer not to say	55 (4)	25 (8)	12 (11)
Gender identity*	**N (%)**	**N (%)**	**N (%)**
Agender	3 (<1)	1 (<1)	0
Female, feminine, or woman	1006 (80)	236 (71)	91 (82)
Genderfluid	3 (<1)	3 (1)	1 (1)
Genderqueer or non-binary	20 (2)	10 (3)	0
Gender non-conforming	4 (<1)	2 (1)	0
Intersex	0	0	0
Male, Masculine, or Man	179 (14)	66 (20)	12 (11)
Not cisgender, but I don't identify with a specific identify	9 (1)	0	0
Questioning or figuring it out	4 (<1)	2 (1)	0
Transgender	6 (1)	2 (1)	0
Two-spirit or other Traditional or Indigenous genders	1 (<1)	0	0
Prefer not to respond	35 (3)	15 (5)	5 (5)
I don't understand the question	5 (<1)	3 (1)	2 (2)
Prefer to self-identify	1 (<1)	0	0

* Participants could select more than one response.

burnout. The PFI includes a 6-item Professional Fulfillment subscale (e.g., "I feel happy at the zoo"; "I feel in control when dealing with difficult problems at the zoo"), a 6-item Interpersonal Disengagement subscale (e.g., "Less empathetic with my colleagues"; "Less connected with zoo animals"), and a 4-item Work Exhaustion subscale (e.g., "A sense of dread when I think about the work I have to do"; "Lacking in enthusiasm at the zoo"). For all items, participants were instructed to reflect on their past two weeks and indicate how well the items described their experience using a 5-point scale ranging from 1 (not at all) to 5 (extremely). An average score was created for the Professional Fulfillment sub-scale; the initial validation study of the PFI reported evidence of the utility of a cut-point (cut point = 3.0) to

TABLE 3 Participants' reported identification as LGBTQ+ and sexual orientation of those who identified as LGBTQ+.

Role	ACHP (n = 1252)	Other (n= 332)	Volunteer (n = 111)
Identify as LGBTQ+*	N (%)	N (%)	N (%)
Yes	249 (20)	76 (23)	9 (8)
No	916 (73)	225 (68)	93 (84)
Unsure	34 (3)	12 (4)	2 (2)
Prefer not to say	53 (4)	19 (6)	7 (6)
Sexual orientation*	**(n=249)**	**(N = 76)**	**N = 9**
Asexual or Ace spectrum	29 (12)	11 (15)	0
Bisexual	106 (43)	34 (45)	4 (44)
Gay	37 (15)	15 (20)	0
Lesbian	42 (17)	12 (16)	4 (44)
Not heterosexual but don't identify with a specific identity	3 (1)	1 (1)	0
Pansexual or Omnisexual	31 (12)	11 (15)	1 (11)
Questioning or figuring it out	5 (2)	2 (3)	0
Straight or heterosexual	3 (1)	0	0
Queer	40 (16)	22 (29)	0
Prefer not to respond	7 (3)	0	0
I don't understand the question	0	0	0
Prefer to self-identify	2 (1)	1 (1)	0

*Participants could select more than one response.

identify dichotomous groupings that distinguish participants who were experiencing professional fulfillment and those who were not. Scores for the Work Exhaustion and Interpersonal Disengagement sub-scales were combined to assess burnout (score 0-10) with higher scores indicating more burnout symptoms. A cut-point of 1.33 was used to identify dichotomous groupings that distinguished participants experiencing burnout from those who were not. Prior studies indicate the PFI is a valid and reliable assessment of professional fulfillment and burnout (11, 56). In the current sample, reliability of the professional fulfillment and burnout scales were excellent (McDonald's omega= 0.895 and 0.910, respectively; Cronbach's alpha= 0.894 and 0.909, respectively).

2.3.2 Perceived organizational support

A modified, 5-item version of the Perceived Organizational Support Scale [POS; (57)] was used to gather staff and volunteer perceptions of the degree to which their organization valued their contributions, and actions the organization might take that could affect the wellbeing of the employee. Responses were measured on a 7-point Likert type scale (1-strongly disagree to 7- strongly agree). Items were adapted so that the word "organization" was replaced with the word "zoo" (i.e., "The zoo values my contribution to its well-being"; "If the zoo could hire someone to replace me at a lower salary it would do so" [reverse scored]; "The zoo fails to appreciate any extra effort from me [reverse scored]; "The zoo strongly considers my goals and values"; "The zoo would ignore any complaint from me [reverse scored]"). Reverse scored items were recoded so that a high score would indicate a higher degree of POS; the total score was obtained by totaling the 5 items (possible range 7-35). Prior research indicates the POS demonstrates adequate reliability and criterion validity across samples (58, 59). Due to the unidimensional structure and high internal reliability of the scale, prior research indicates shorter versions of the scales do not appear to be problematic (58). Reliability of the adapted 5-item scale utilized in the current study was excellent (McDonald's omega = 0.880; Cronbach's alpha = 0.880).

2.3.3 Anxiety and depression

The Patient Health Questionnaire for Depression and Anxiety (PHQ-4), a brief, 4-item self-report measure used to screen for depression and anxiety (60, 61), was used to assess anxiety and depression. The PHQ-4 was developed as a brief tool to identify the severity and frequency of anxiety and depression in community samples. The two-item Anxiety scale prompts participants to evaluate their experiences related to "feeling nervous, anxious or on edge" and "not being able to stop worrying" (possible range: 0-8); The 2-item Depression scale prompts participants to evaluate their experiences related to "feeling down, depressed or hopeless" and "little interest or pleasure in doing things" (possible range 0-8). In the study, we used cut-off scores of 3 to indicate "yellow flags" and scores of 5 or greater as "red flags" for the presence of depression and/or anxiety (61). Prior research indicates the English language version of the PHQ demonstrates high reliability and validity across samples and population groups with varying social locations and cultures (61–65). Prior studies also indicate this tool is a reliable and valid instrument for screening anxiety and depression in both clinical and non-clinical populations (66). Reliability estimates in the current sample for depression (Cronbach's alpha = 0.866) and anxiety (Cronbach's alpha = 0.868) were excellent.

2.3.4 Resilience

We used the Brief Resilience Scale [BRS; (67)] to gain insights into the extent to which zoo staff and volunteers perceive themselves as resilient (having the ability to recover from stress or "bounce back" from adverse events and contexts). The BRS is comprised of six items (e.g., "I tend to bounce back quickly after hard times"; "It does not take me long to recover from a stressful event"). Participants rate the items on a five-point Likert scale (1 = strongly disagree to5 = strongly agree). Three items are reverse coded so that for the total score, a higher score indicates a greater sense of perceived resilience. Prior studies have established the following score interpretation ranges and cutoffs: Low Resilience=

1.00–2.99; Normal Resilience= 3.00–4.30; High Resilience= 4.31–5.00. Previous research indicates that the BRS is reliable and demonstrates evidence of construct validity across diverse samples (68). In the current study, reliability was excellent (McDonald's omega = 0.869; Cronbach's alpha= 0.869).

2.3.5 Types of animal-related loss

Participants were provided with a list of animal-related losses and asked to select all that they had experienced in the past 12 months. Specifically, the question read: "There are several types of loss that can occur when working or volunteering within a zoo setting. Which of the following animal-related losses have you experienced in the past 12 months? Select all that apply." The options included: 1) Anticipated death of an animal I worked closely with, 2) Unexpected death of an animal I worked closely with, 3) Transfer of an animal I worked closely with to a different zoo, and 4) Change in job that led to no longer working with a particular animal. Participants also had the option of selecting "I have not experienced animal-related losses in the past 12 months." For each response selected, participants were asked a series of follow up questions to understand a) when the loss occurred (e.g., "You indicated that you experienced the anticipated death of an animal you worked closely with. Think about your most recent loss. When did that anticipated loss occur?") and b) how bonded they were with the animal they lost (i.e., "How bonded were you with that animal")?. Participants' level of bond with the animal they lost was measured on a 10-point slider scale, from "Not bonded at all" to "Very bonded." Response options for the question regarding the timing of the loss were as follows: in the past month, 2-3 months ago, 4-6 months ago, 7-8 months ago, and 9-12 months ago.

Participants who indicated that they had *not* experienced animal-related loss in the past 12 months were then asked if they had *ever* experienced any animal-related losses while working at their current zoological institution. Response options for this question were identical to those in the question about their experiences in the past 12 months; however, their level of bond and the timing of the loss were not assessed.

2.3.6 Demographic questions

Demographic questions were asked at the end of the survey and included questions about participants' age, gender identity, sexual orientation, race, ethnicity, and education.

2.4 Data analysis

After downloading the data from the Alchemer survey platform, descriptive statistics, Analyses of Variance tests, Chi-Square tests, and multiple linear regression were conducted with IBM SPSS Version 26 (IBM, Armonk, NY, USA). Descriptive statistics were calculated to characterize participant demographics. Analyses of variance tests and Chi Square tests were used to assess for differences between the three groups of participants (Animal Care/Health Professional, Other, and Volunteer). We performed a series of multiple linear regression analyses to determine predictive variables for Job Fulfillment, Burnout, Depression, Anxiety, and POS. The potential predictor variables included Animal Loss within past month (yes/no), Bond score, Resiliency score, Ritual following death (yes/no), Age (29 and younger, 30-39 years of age, 40-49 years of age, 50 and older), Length of time working in the field (11 months or less, 1-4 years, 5-9 years, 10-19 years, 20 or more years) and Identification as LGBTQ+ (yes/no). All variables were entered into the models simultaneously. Statistical significance level was set at $p = 0.05$.

3 Results

Participants were asked to indicate from a list of 19 options (including 'Other') their role at the zoo. The most common roles included Animal care specialist (n = 923, 55%), Other (n = 184, 11%), Volunteer (n = 110, 7%), and Curator (n = 105, 6%). Because many of the identified roles contained very small numbers, to ensure anonymity, all paid employees' responses, including each response under 'Other', were recoded into ACHP Professional or Other, resulting in three groupings ("Animal Care/Health Professional" (n = 1252, 74%), "Other" (332, 20%) and "Volunteer" (111, 7%)). The majority of employees reported working full-time while volunteers reported volunteering an average of 17 hours per week (Table 1).

Participants were asked to indicate, from a series of possible 15 options (including 'Other' and 'Not applicable'), the animals they primarily work with, with the ability to select more than one type. The most common responses for ACHPs were Birds (656, 52%) and Small Mammals (540, 43%). The most common animal responses for other staff were Ambassador animals (109, 33%) and Reptiles (61, 18%), while volunteers reported working most often with Primates (23, 21%), Birds (18, 16%) and Hoofstock (18, 16%) (Table 4).

3.1 The Stanford Professional Fulfillment Index

The mean of all participants' Professional Fulfillment PFI score was 2.44 (SD = 0.87). Using the cut-off point of 3.0 or higher, 31% of the total sample reported experiencing professional fulfillment. Analysis of Variance was used to explore differences in fulfillment level between each of the three roles: ACHPs, Other, and Volunteer. There was a significant difference between each group (F = 73.43, p<.001), with Volunteers reporting the highest rate of Professional Fulfillment (X= 3.18, SD = 0.67), followed by Other (X= 2.68, SD = 0.86) and then ACHPs (X= 2.31, SD = 0.84). A total of 76 (68%) Volunteers met or exceeded the cut-off for Professional Fulfillment, compared to 140 (42%) Others and 307 (25%) ACHPs.

3.2 Stanford Professional Burnout Index

The overall mean for all participants for the 10-item PFI Burnout scale was 1.34 (SD = 0.83). Using Analysis of Variance, a significant difference was found between the ACHPs, Other, and

TABLE 4 Primary animal worked with as reported by participants, divided by role.

Role*	ACHP (n = 1252)		Other (n= 332)	Volunteer (n = 111)
	N (%)	Mean bond score (1-10) and SD	N (%)	N (%)
Ambassador animals	382 (31)	5.94 (2.15)	109 (33)	17 (15)
Amphibians	304 (24)	5.45 (2.25)	54 (16)	4 (4)
Birds	656 (52)	6.10 (2.11)	58 (18)	18 (16)
Carnivores	598 (48)	6.26 (2.18)	37 (11)	14 (13)
Domestic animals	259 (21)	5.91 (2.12)	44 (13)	4 (4)
Elephants/pachyderms	197 (16)	5.97 (2.28)	17 (5)	13 (12)
Fish	214 (17)	5.30 (2.19)	19 (6)	3 (3)
Hoofstock	507 (41)	6.18 (2.06)	37 (11)	18 (16)
Invertebrates	254 (20)	5.52 (2.25)	46 (14)	5 (5)
Marine mammals	158 (13)	5.76 (2.26)	14 (4)	1 (1)
Primates	438 (35)	6.15 (2.26)	28 (8)	23 (21)
Reptiles	454 (36)	5.88 (2.26)	61 (18)	8 (7)
Small mammals	540 (43)	6.22 (2.26)	55 (16)	16 (14)
Other	36 (3)	–	19 (6)	9 (8)
Not applicable	20 (2)	–	166 (50)	38 (34)

*Participants could select more than one response.

Volunteer groups ($F = 146.08$, $p < .0001$), with ACHPs reporting the highest rates of Burnout ($X = 1.51$, $SD = 0.79$), followed by Other ($X = 1.04$, $SD = 0.79$) and Volunteers ($X = 0.35$, $SD = 0.45$). Based on the cut-point of 1.33 used to identify participants experiencing burnout, a total of 693 (55%) ACHPs were at or above the threshold, compared to 105 (32%) Others and 5 (5%) Volunteers.

3.3 Perceived Organizational Support Scale

The mean for the sum of the POS Scale for all participants was 20.51 ($SD = 7.76$). There was a significant difference, based on Analysis of Variance results, between each group ($F = 73.89$, $p < .0001$), with Volunteers scoring the highest ($X = 27.95$, $SD = 7.76$), followed by Other ($X = 22.78$, $SD = 7.13$) and ACHPs ($X = 19.33$, $SD = 7.65$).

3.4 The Patient Health Questionnaire - depression

The mean sum of the two items from the PHQ-4 that measure depression was 1.79 ($SD = 1.81$). Using the cutoff value of 3 or above to identify potential depression, 486 (29%) participants met or exceeded this cutoff. There was a significant difference, based on Analysis of Variance results, between all three groups ($F = 45.42$, $p < .001$), with ACHPs scoring the highest ($X = 1.99$, $SD = 1.83$), followed by Others ($X = 1.48$, $SD = 1.72$) and Volunteers ($X = 0.45$, $SD = 0.98$). A total of 407 (33%) ACHPs met or exceeded the cutoff for depression. This number was 74 (22%) for Others and 4 (4%) for Volunteers.

3.5 The Patient Health Questionnaire – anxiety

The mean sum of the two items from the PHQ-4 that measure anxiety was 2.30 ($SD = 1.88$). Using the cut off value of 3 or above to identify potential anxiety, 645 (38%) met the threshold for anxiety. Using Analysis of Variance, a significant difference was found between all three groups ($F = 68.21$, $p < .001$), with ACHPs scoring the highest ($X = 2.54$, $SD = 1.87$), followed by Others ($X = 1.99$, $SD = 1.77$) and Volunteers ($X = 0.54$, $SD = 1.09$). A total of 532 (43%) ACHPs, 107 (32%) Others, and 5 (5%) Volunteers met or exceeded the cutoff for moderate to severe anxiety.

3.6 Brief Resilience Scale

The mean for the Brief Resilience Scale for all participants was 2.54 ($SD = 1.09$). Using the cutoff values of Low (1.00 – 2.99), Normal (3.00 – 4.30) and High (4.31 – 5.00), 402 (24%) participants had scores indicating low resilience, 1123 (66%) had scores indicating normal resilience, and 170 (10%) had scores indicating high resilience. Analysis of Variance results found a significant difference ($F = 3.37$, $p = .034$) between ACHPs ($X = 3.41$, $SD = 0.73$) and Volunteers ($X = 3.59$, $SD = 0.75$). There were no differences between Others ($X = 3.41$, $SD = 0.70$) and ACHPs or Volunteers.

The number of ACHPs whose scores suggested high resilience was 124 (10%), compared to 27 (8%) of Others and 19 (17%) of Volunteers.

3.7 Types of animal-related loss

For ACHPs, the most common losses in the past 12 months included Unexpected death, experienced by 998 (80%), and Anticipated loss, experienced by 921 (74%). Over half of the ACHPs reported these losses had occurred either within the past month or within the last 2-3 months. Reported mean bond level for all four types of losses ranged from 8.15 (SD = 2.22) for Change in Job, to 6.06 (SD = 2.74) for Unexpected Death. If participants had not experienced any of the four types of loss within the past 12 months, they were asked if they had ever experienced it. Approximately 80% of these participants reported having experienced Unexpected death or Anticipated death at some point, while 48% reported having experienced a Transfer or a Change in job (Table 5). Anticipated death and Unexpected death were also the most commonly reported types of loss for "Other" participants and Volunteers (Tables 6, 7).

A larger percentage of Others and Volunteers, compared to ACHPs, reported not having experienced these types of losses within the past 12 months (Anticipated loss [X^2 = 201.62, p<.001]; Unexpected loss [X^2 = 140.42, p<.001], Transfer [X^2 = 102.56, p<.001]; and Change in job [X^2 =30.73, p<.001]). Similarly, Others and Volunteers reported they had never experienced any of these types of losses more often than ACHPs (Anticipated loss [X^2 = 99.16, p<.001]; Unexpected loss [X^2 = 76.13, p<.001], Transfer [X^2 = 34.25, p<.001]; Change in job (X^2 = 45.20, p<.001]) (Tables 5–7). For further analysis, these four types of losses were combined to create one variable that denoted any animal loss. The amount of time since each type of loss was also combined and recoded as a binary variable (within the past month (yes/no). A total of 289 (17%) participants said their zoo had any formal process or ritual that was performed following the death of an animal, 1051 (62%) said no and 355 (21%) reported they did not know.

Because a substantial number of Others (166, 50%) and Volunteers (38, 34%) reported that they do not work directly with animals, the decision was made to analyze the potential predictive value of animal loss (in addition to job and personal factors), on Job Fulfillment, Burnout, Depression, Anxiety, and POS for ACHPs only.

3.8 Multiple linear regression analyses

3.8.1 Job fulfillment

The multiple linear regression predicting job fulfillment was significant ($F(12)$ = 12.33, p < 0.001), with an R^2 of 0.134. Significant predictors of Job Fulfillment included Ritual (B = 0.251; p < 0.001; higher Job Fulfillment reported by those having a ritual) and Resilience (B = 0.351, p <.001; higher Job Fulfillment reported by those with higher Resilience scores) (Table 8).

3.8.2 Burnout

The multiple linear regression predicting burnout was significant ($F_{(12)}$ = 14.49, p < 0.001, R^2 = 0.154). Significant predictors of burnout included Ritual (B = -0.191; p = 0.002; higher burnout reported by those with no ritual), Resilience (B = -0.354, p <.001; higher burnout reported by those with lower Resilience), and age (B = 0.336, 0.282 p = .004; higher burnout reported by those ages 30-39 and 29 years of age and younger compared to participants 40 years of age or older) (Table 9).

TABLE 5 Animal loss: Type, time and bond for ACHP (n = 1252).

Loss in past 12 months	Bond		Time					
			In past month	2-3 months	4-6 months	7-8 months	9-12 months	Ever experienced (but not in past 12 months) n = 80)
			N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Anticipated death	M 6.09 (SD 2.57)	In past 12 months n = 921	243 (27)	241 (27)	183 (21)	87 (10)	138 (16)	62 (78)
Unexpected death	6.06 (SD 2.74)	In past 12 months n = 998	340 (35)	262 (27)	157 (16)	86 (9)	123 (13)	65 (81)
Transfer	6.52 (SD 2.69)	In past 12 months n = 583	123 (21)	150 (26)	154 (26)	63 (11)	93 (16)	38 (48)
Change in job	8.15 (SD 2.22)	In past 12 months n = 247	42 (17)	50 (20)	54 (22)	32 (13)	69 (28)	38 (48)

TABLE 6 Animal loss: Type, time and bond for Other (n = 332).

Loss in past 12 months	Bond		Time					
			In past month	2-3 months	4-6 months	7-8 months	9-12 months	Ever experienced (but not in past 12 months) n = 131)
			N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Anticipated death	M 4.86 (SD 2.31)	In past 12 months n = 119	30 (25)	40 (34)	27 (23)	9 (8)	13 (11)	18 (14)
Unexpected death	5.03 (SD 2.72)	In past 12 months n = 160	50 (31)	41 (26)	38 (24)	14 (9)	17 (11)	28 (21)
Transfer	5.28 (SD 2.82)	In past 12 months n = 61	19 (31)	15 (25)	16 (26)	5 (8)	6 (10)	15 (12)
Change in job	7.24 (SD 2.49)	In past 12 months n = 33	2 (6)	9 (27)	11 (33)	3 (9)	8 (24)	13 (10)

3.8.3 Depression

The multiple linear regression predicting depression was significant ($F_{(12)}$ = 16.34, p < 0.001), with an R^2 of 0.171. Significant predictors of depression included Ritual (B = -0.337; p = 0.017; higher Depression reported by those with no ritual), Bond (B = 0.095, p <.001; higher depression reported by those with a stronger bond) Resilience (B = -0.872, p <.001 higher depression reported by those with lower Resilience), and LGBTQ+ (B = 0.292, p = .033; higher depression scores reported by those who identified as LGBTQ+) (Table 10).

TABLE 7 Animal loss: Type, time and bond for Volunteers (n=111).

Loss in past 12 months	Bond		Time					
			In past month	2-3 months	4-6 months	7-8 months	9-12 months	Ever experienced (but not in past 12 months) n = 35)
			N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Anticipated death	M 4.81 (SD 2.10)	In past 12 months n = 34	2 (6)	13 (38)	11 (32)	2 (6)	6 (18)	4 (11)
Unexpected death	5.29 (SD 2.64)	In past 12 months n = 54	17 (32)	10 (19)	14 (26)	6 (11)	7 (13)	10 (29)
Transfer	6.00 (SD 2.59)	In past 12 months n = 29	5 (17)	7 (24)	6 (21)	4 (14)	7 (24)	9 (26)
Change in job	4.63 (SD 0.74)	In past 12 months n = 8	–	–	1 (13)	1 (13)	6 (75)	3 (9)

TABLE 8 Results of the multiple linear regression model predicting Job Fulfillment as a function of animal loss within past month, bond score, resiliency score, formal process/ritual following death, age, length of time working in the field, and identification as LGBTQ+.

ANOVA						
Model	Sum of Squares	df	Mean Squares	F	Sig.	
Regression Total	90.255 5826.42	12 966	7.52	12.33	<0.001	
Coefficients (Dependent Variable: Job Fulfillment)					95.0% CI	
Variable	Coefficient (B)	Std. Error	t	Sig.	Lower Bound	Upper Bound
(Constant)	1.189	.172	6.922	<.001	.852	1.526
Ritual - yes	.251	.065	3.832	<.001	.122	.379
Ritual - no	0	.	.	.	.	.
Bond	.001	.012	.113	.910	-.023	.025
Loss in past month – yes	-.082	.051	-1.602	.109	-.182	.018
Loss in past month - no	0	.	.	.	.	.
Resilience	.351	.035	10.061	<.001	.283	.420
Age 29 and younger	-.172	.120	-1.431	.153	-.408	.064
Age 30-39	-.155	.108	-1.437	.151	-.366	.057
Age 40-49	.008	.105	.072	.943	-.198	.213
Age 50 and older	0	.	.	.	.	.
Time in field – 11 month/less	.177	.148	1.200	.230	-.113	.467
Time in field – 1-4 years	.087	.112	.774	.439	-.134	.308
Time in field – 5-9 years	.037	.110	.333	.740	-.180	.253
Time in field – 10-19 years	-.069	.102	-.671	.502	-.269	.132
Time in field – 20+	0	.	.	.	.	.
LGBTQ+ yes	-.048	.064	-.760	.447	-.173	.077
LGBTQ+ no	0	.	.	.	.	.

3.8.4 Anxiety

The multiple linear regression predicting anxiety was significant ($F_{(12)} = 18.37$, $p < 0.001$), with an R^2 of 0.188. Significant predictors of anxiety included Bond (B = 0.067, p =.012; higher anxiety reported by those with a stronger bond) and Resilience (B = -0.969, p <.001; higher anxiety reported by those with lower Resilience) (Table 11).

3.8.5 Perceived organizational support

The multiple linear regression predicting POS was significant ($F_{(12)} = 13.56$, $p < 0.001$, R^2 =0.146). Significant predictors of POS included Ritual (B = 2.71, p <.001; higher POS reported by those with a ritual), Bond (B= -0.272, p=.016; lower POS reported by those with a stronger bond) Resilience (B = 2.63, p <.001; higher POS reported by those with higher Resilience), Age (B = -4.22, -2.89, p <.001; lower POS reported by participants 39 years of age or younger compared to those 40 years of age and older), and time in the field (B = 3.07, p =.016; higher POS reported by those in the field either 11 months/less or 20 years or more when compared to those in the field between 1-19 years) (Table 12).

4 Discussion

Despite increased recognition of burnout and mental health problems among ACHPs in other work settings (animal shelters, veterinary practice), the wellbeing of those who work and/or volunteer in zoo settings has received minimal research attention. This study addresses this gap, giving us a better understanding of U.S. zoo staff and volunteers' job fulfillment, POS, burnout, mental health, resiliency, and experiences of animal loss. Our findings suggest that ACHPs in zoo settings face similar struggles as those in other settings, indicating a need to prioritize supportive services for ACHPs within zoo settings.

4.1 Job fulfillment and perceived organizational support

Only 31% of the total sample exceeded the cut-off for professional fulfillment. ACHPs reported the lowest levels of professional fulfillment (25%), significantly lower than other staff

TABLE 9 Results of the multiple linear regression model predicting Burnout as a function of animal loss within past month, bond score, resiliency score, formal process/ritual following death, age, length of time working in the field, and identification as LGBTQ+.

ANOVA						
Model	Sum of Squares	df	Mean Squares	F	Sig.	
Regression Total	89.79 2843.90	12 966	7.48	14.49	<0.001	
Coefficients (Dependent Variable: Burnout)					95.0% CI	
Variable	Coefficient (B)	Std. Error	t	Sig.	Lower Bound	Upper Bound
(Constant)	2.629	.158	16.635	<.001	2.319	2.939
Ritual - yes	-.191	.060	-3.176	.002	-.309	-.073
Ritual - no	0	.	.	.	.	.
Bond	.012	.011	1.076	.282	-.010	.034
Loss in past month – yes	-.010	.047	-.211	.833	-.102	.082
Loss in past month - no	0	.	.	.	.	.
Resilience	-.354	.032	-11.030	<.001	-.417	-.291
Age 29 and younger	.336	.111	3.039	.002	.119	.553
Age 30-39	.282	.099	2.849	.004	.088	.476
Age 40-49	.086	.096	.894	.371	-.103	.275
Age 50 and older	0	.	.	.	.	.
Time in field – 11 month/less	-.358	.136	-2.631	.009	-.624	-.091
Time in field – 1-4 years	-.216	.103	-2.092	.037	-.419	-.013
Time in field – 5-9 years	-.187	.102	-1.841	.066	-.386	.012
Time in field – 10-19 years	-.102	.094	-1.087	.277	-.287	.082
Time in field – 20+	0	.	.	.	.	.
LGBTQ+ yes	.028	.059	.476	.634	-.087	.143
LGBTQ+ no	0	.	.	.	.	.

(42%), or volunteers (68%). Our findings mirror prior studies among ACHPs in other settings that have reported low rates of professional fulfillment (11, 49). Given the association between professional fulfillment and levels of well-being and burnout among ACHPs (11, 49), investing in programs, policies, and practices that better support staff, particularly ACHPs, in their professional development is key for zoos that want to prioritize employee wellbeing.

We also found evidence of differences in POS by role. Volunteers reported feeling the most organizational support, followed by other staff, and then AHCPs. While possible POS scores ranged from 7 to 35; the average score for ACHPs was 19 (compared to 23 for Others and 28 for Volunteers). These scores suggest that zoos have an opportunity to improve their supportive services. Because prior research suggests POS is negatively associated with burnout, grief, stress, and several indicators of poor mental health (8, 42, 46–48), investing resources in strengthening and maintaining perceptions of organizational support may have benefits to both zoo professionals and volunteers.

4.2 Burnout, mental health, and resiliency

In the current study, we found that ACHPs, compared to other staff and volunteers, reported the highest rates of burnout. A majority (55%) of ACHPs scored at or above the burnout threshold, compared to 32% of other staff and 5% of volunteers. This finding is consistent with prior research indicating higher burnout scores in careers that include higher degrees of animal contact (69). The rate of burnout among ACHPs in the current study is comparable to those reported for animal shelter and veterinary professionals (e.g., (11, 54, 70). This rate also mirrors the estimated percentage of human medical professionals who experience burnout, with most estimates exceeding 50% (11, 71–73).

Our findings support prior evidence that ACHPs are at increased risk for anxiety and depression. In the general U.S. population, the estimated rate of past-year anxiety disorder diagnoses (of any type) and past-year major depressive episode is estimated to be 19.1% and 8.3%, respectively (74–76). In the current

TABLE 10 Results of the multiple linear regression model predicting Depression as a function of animal loss within past month, bond score, resiliency score, formal process/ritual following death, age, length of time working in the field, and identification as LGBTQ+.

ANOVA						
Model	Sum of Squares	df	Mean Squares	F	Sig.	
Regression Total	556.05 18972.00	12 966	46.34	16.34	<0.001	
Coefficients (Dependent Variable: Depression)					95.0% CI	
Variable	Coefficient (B)	Std. Error	t	Sig.	Lower Bound	Upper Bound
(Constant)	6.241	.370	16.852	<.001	5.514	6.968
Ritual - yes	-.337	.141	-2.389	.017	-.614	-.060
Ritual - no	0	.	.	.	.	.
Bond	.095	.026	3.604	<.001	.043	.147
Loss in past month – yes	.002	.110	.022	.982	-.213	.218
Loss in past month - no	0	.	.	.	.	.
Resilience	-.872	.075	-11.580	<.001	-1.020	-.724
Age 29 and younger	.003	.259	.012	.990	-.505	.512
Age 30-39	-.147	.232	-.633	.527	-.602	.308
Age 40-49	-.115	.226	-.508	.612	-.558	.328
Age 50 and older	0	.	.	.	.	.
Time in field – 11 month/less	.397	.319	1.246	.213	-.228	1.022
Time in field – 1-4 years	.303	.242	1.249	.212	-.173	.778
Time in field – 5-9 years	.235	.238	.986	.324	-.232	.702
Time in field – 10-19 years	.296	.220	1.344	.179	-.136	.729
Time in field – 20+	0	.	.	.	.	.
LGBTQ+ yes	.292	.137	2.129	.033	.023	.562
LGBTQ+ no	0	.	.	.	.	.

sample, 43% of ACHPs met or exceeded our "yellow flag" cutoff for the presence of anxiety, providing initial evidence that rates of anxiety may be higher among zoo ACHPs than in the general population. We also found that the rate of moderate to severe anxiety was 32% and 5% for other staff and volunteers, respectively. Thus, other zoo staff, regardless of having a direct role in animal care/health, demonstrate elevated rates of anxiety. Similar patterns were found for depression. 33% of ACHPs and 22% of other staff met our cut-point for the presence of depression, whereas only 4% of volunteers met this criterion.

When we assessed resilience, we found that 24% of participants had scores indicating low resilience, 66% were in the normative range, and 10% had scores indicating high resilience. More specifically, 10% of ACHPs' scores suggested high resilience, compared to 8% of Others and 17% of Volunteers. Accordingly, a notable proportion of paid staff could benefit from opportunities to develop or enhance their adaptive coping strategies to foster resilience in the workplace. Results of our regression analyses provide further support for this assertion. Our findings indicated that higher levels of resiliency were associated with lower levels of burnout, depression, and anxiety, and higher levels of professional fulfillment and POS. Given that only 10% of ACHPs and 8% of other staff scored in the high resilience category, our findings suggest that investing in helping zoo professionals develop resiliency through adaptive coping is an important area of opportunity for zoos who aim to promote employee wellbeing. In addition, there is increasing recognition that resiliency is also something that can be fostered on a team level. Team resilience has been defined as the processes of "managing pressure effectively across the team as a whole […], that further strengthen the capacity of the team to deal with future challenges in adversity" (77). The premise of team resilience is that adverse stressors can negatively affect team members' health and team performance, and as a result, impact a team's overall functioning level (78). While most stress research has focused on individuals' stress and resiliency, many organizations are recognizing the need to support teams, especially during and after adverse events (79). Zoos that prioritize team and individual resilience could impact not only their employees' mental health, but the functionality of the organization.

TABLE 11 Results of the multiple linear regression model predicting Anxiety as a function of animal loss within past month, bond score, resiliency score, formal process/ritual following death, age, length of time working in the field, and identification as LGBTQ+.

ANOVA						
Model	Sum of Squares	df	Mean Squares	F	Sig.	
Regression Total	642.73 23801.00	12 966	53.56	18.37	<0.001	
Coefficients (Dependent Variable: Anxiety)					95.0% CI	
Variable	Coefficient (B)	Std. Error	t	Sig.	Lower Bound	Upper Bound
(Constant)	7.148	.375	19.037	<.001	6.411	7.885
Ritual - yes	-.181	.143	-1.264	.207	-.461	.100
Ritual - no	0	.	.	.	.	.
Bond	.067	.027	2.511	.012	.015	.119
Loss in past month – yes	-.100	.112	-.897	.370	-.319	.119
Loss in past month - no	0	.	.	.	.	.
Resilience	-.969	.076	-12.699	<.001	-1.119	-.820
Age 29 and younger	.335	.263	1.275	.203	-.181	.850
Age 30-39	.211	.235	.897	.370	-.251	.672
Age 40-49	.265	.229	1.156	.248	-.184	.714
Age 50 and older	0	.	.	.	.	.
Time in field – 11 month/less	.323	.323	.999	.318	-.311	.956
Time in field – 1-4 years	.325	.246	1.324	.186	-.157	.808
Time in field – 5-9 years	.148	.241	.615	.539	-.325	.622
Time in field – 10-19 years	-.063	.223	-.284	.777	-.502	.375
Time in field – 20+	0	.	.	.	.	.
LGBTQ+ yes	.171	.139	1.227	.220	-.102	.444
LGBTQ+ no	0	.	.	.	.	.

4.3 Animal bonds, animal loss, and rituals

In addition to job fulfillment, POS, and mental health, we also examined participants' bonds with the animals they care for. We found that reported levels of bond were relatively consistent regardless of the type of species/taxa cared for by participants. For ACHPs, the mean level of reported bond (range 1-10) across all four types of losses (anticipated, unexpected, transfer, job change) ranged from 6.06 to 8.15. The mean bond for other staff ranged from 4.86 to 7.25 and volunteer bond means ranged from 4.64 to 6.0. Thus, regarding experiences of animal loss, individuals who worked closely with animals reported, on average, higher bonds with these animals. Furthermore, results of our regression analyses showed that level of ACHP's bond with animals was positively and significantly associated with depression and anxiety, such that those with stronger bonds had higher levels of depression and anxiety.

Results of this study identified the most common losses experienced by ACHPs in the past year were unexpected death (experienced by 80%) and anticipated loss (experienced by 74%), with more than half of these losses occurring within the past 3 months. These types of death were also the most frequently reported types of loss for other staff and volunteers (37% and 50%, respectively). A larger percentage of other staff and volunteers, compared to ACHPs, reported not having experienced these types of losses (within the past year or ever at their current zoological institution). Among those who had not experienced a loss in the past year, 80% reported having experienced an unexpected death or anticipated death at some point.

Although animal loss is a common experience for ACHPs, only 17% of participants in our sample (16.6% of ACHPs) indicated that their zoo had a formal process or ritual that was performed following the death of an animal. This finding is important given results of the regression models suggesting that although animal loss is not a significant predictor of any outcome examined in the current study, having a formal ritual or process is positively associated with job fulfillment and POS and negatively associated with depression and burnout. This suggests that despite the high prevalence of loss experiences among ACHPs, how these losses are handled may be more important in the context of ACHPs' wellbeing. Additionally, our findings concerning participants'

TABLE 12 Results of the multiple linear regression model predicting Perceived Organizational Support as a function of animal loss within past month, bond score, resiliency score, formal process/ritual following death, age, length of time working in the field, and identification as LGBTQ+.

ANOVA						
Model	Sum of Squares	df	Mean Squares	F	Sig.	
Regression Total	8434.58 413650.00	12 966	702.88	13.56	<0.001	
Coefficients (Dependent Variable: Perceived Organizational Support)					95.0% CI	
Variable	Coefficient (B)	Std. Error	t	Sig.	Lower Bound	Upper Bound
(Constant)	14.060	1.583	8.882	<.001	10.953	17.166
Ritual - yes	2.712	.603	4.499	<.001	1.529	3.895
Ritual - no	0	.	.	.	.	.
Bond	-.272	.113	-2.420	.016	-.493	-.051
Loss in past month – yes	-.641	.470	-1.362	.174	-1.564	.282
Loss in past month - no	0	.	.	.	.	.
Resilience	2.630	.322	8.173	<.001	1.999	3.262
Age 29 and younger	-4.216	1.107	-3.807	<.001	-6.389	-2.043
Age 30-39	-2.890	.992	-2.914	.004	-4.836	-.944
Age 40-49	-1.025	.965	-1.063	.288	-2.919	.869
Age 50 and older	0	.	.	.	.	.
Time in field – 11 month/less	3.072	1.362	2.256	.024	.399	5.744
Time in field – 1-4 years	1.202	1.036	1.160	.246	-.831	3.235
Time in field – 5-9 years	.272	1.017	.268	.789	-1.723	2.268
Time in field – 10-19 years	-.554	.942	-.588	.556	-2.403	1.295
Time in field – 20+	0	.	.	.	.	.
LGBTQ+ yes	-.761	.587	-1.297	.195	-1.912	.390
LGBTQ+ no	0	.	.	.	.	.

bonds with animals highlight that *all* animal loss is important, regardless of species. Given that higher value and attention tends to be placed on charismatic animals, such as small and large mammals (80, 81), it is important that zoos practice equity in honoring experiences of loss among those who work with all species, including fish, amphibians, and reptiles.

4.4 Demographic considerations

In the current study, we found that 20% of study participants identified as LGBTQ+. Prior research suggests that LGBTQ+ people make up approximately 6% of the U.S. workforce (81); moreover, representation of LGBTQ+ identities in the general U.S. population is estimated at 7% (82, 83). Thus, the representation of LGBTQ+ people in the current study is an important finding. There are few potential explanations for the higher-than-expected rate of LGBTQ + representation in the current study. For example, prior studies indicate a high degree of orientation towards animals, and value placed on animals, among members of the LGBTQ+ community (84–88). There is also some evidence that LGBTQ+ individuals, particularly early career workers, report lower salary expectations than heterosexual individuals and are more likely to embrace "altruistic" work values and to indicate a career choice in the nonprofit sector (89). Thus, working in zoos may be particularly appealing to some members of the LGBTQ+ community.

Results of this study also suggest that LGBTQ+ status is positively associated with depression among ACHPs, even when adjusting for the effects of participant age, time in the field, experiences of animal loss, bonds with animals, and individual resiliency. This finding is not surprising given that exposure to minority stressors results in increased levels of depression in the LGBTQ+ population, who, overall, are impacted by disproportionate rates of mental health issues when compared to their cisheterosexual peers (84, 90). Prior research also suggests that LGBTQ+ workers with poor or neutral mental health have greater odds of working in low-wage sectors (91). The issue of low pay and living wages for those working in zoo settings has been an ongoing topic of discussion in the industry (39, 92–96); however, more contemporary, rigorous and representative data are needed to support these claims. To promote equity within the industry, future research on the experiences and wellbeing of LGBTQ+ people in zoo settings is warranted. We recommend that

future studies in this area capture socioeconomic data in tandem with LGBTQ+ workers' mental health and explore the representation of LGBTQ+ identities across all levels of zoos' organizational structure (e.g., formal leadership roles, managers vs. non-managers, hourly staff) to test whether LGBTQ+ representation is equitable across job function and pay grades. Given the limitations of the current sample concerning other forms of demographic diversity, research intentionally designed to identify the representation and experiences of individuals with other marginalized identities in the zoo industry (e.g., racialized staff and/or those with disabilities) is also an important direction for future research (97).

Our results also suggest that ACHPs' age and time in the field are important demographic factors that warrant further attention in relation to zoo professionals' wellbeing. Results of our regression model predicting burnout indicated that ACHPs ages 39 and younger may be most at risk for burnout, compared to staff who are 40 years of age or older. However, it is possible that this result is confounded by individuals' position or role within the organization. Individuals in the 40+ age group may be more likely to have leadership positions that afford more agency and control in the workplace, thereby contributing to lower levels of burnout in the current sample (7, 21, 31). We recommend that future studies assess these factors in more detail. Age was also a significant predictor in our regression model predicting POS, which indicated that participants 39 years of age or younger, compared to those 40 years of age and older, reported lower levels of organizational support. Regarding age group differences, it is interesting to consider that individuals in the current sample who are 18 to 29 years of age represent Gen Z and Millennials, whereas the 40+ groups reflect individuals on the Millennial/Gen X cusp, Gen X, and Baby Boomers. Thus, it is possible that generational differences may influence perceptions of organization support (8, 98) or that ways that zoos invest in and demonstrate support for staff are more aligned with older generations. Lastly, ACHPs who have been in the field either 6 to 11 months or 20 years or more had higher levels of perceived organization support compared to those in the field 1-19 years. One potential explanation for this finding is that staff who are in their first year on the job are still in the onboarding process and perceive a higher degree of support due to organizational efforts to integrate them into their new role. Moreover, individuals who have been in the field more than 20 years may be those whose values and occupational needs are well aligned with the culture of their organization. Our results suggest that better understanding the organizational support needs of early and mid-career ACHP is an important direction for future inquiry.

4.5 Implications and future directions for research

Promoting mental health among all employees and volunteers, but especially ACHPs, in zoo settings is not only important for enhancing their wellbeing but could also help to mitigate the potentially harmful impact of poor mental health and burnout on the health and welfare of animals under human care. Although the association between physician burnout, professional inefficiencies, and suboptimal patient care is well documented in human medicine (99), less is known about the impact of ACHPs' burnout on the animals under their care. Brando et al. (39) surveyed zoo and aquarium professionals and identified common themes regarding these professionals' lack of ability to feel empowered to do their best for animal welfare. The study also identified links between staff welfare and perceptions of animal welfare and suggested that by taking better care of their people via reduction of stressors, zoos can improve the ability of their staff to care for animals. Future research should explore whether programs that aim to support ACHP wellbeing (e.g., GRAZE [Growing Resiliency in Aquarium and Zoo Employees]) have indirect effects on the wellbeing of animals under human care in zoos. Furthermore, it will be important to assess if this effect is evident when utilizing objective measures of animal health and wellbeing (e.g., biomarkers), as well as zoo guests' perceptions of animal care. Additionally, research suggests associations between professional burnout and general safety compliance (100). Because zoo-based ACHPs work with captive wildlife that may pose risks to staff and guest safety, as well as machinery and heavy equipment, understanding the links between burnout, mental health, and occupational safety and compliance in the zoo industry are also important directions for future research.

By offering Employee Assistance Programs (EAPs), zoos can provide confidential access to professional counseling services for staff. These programs can offer problem assessment, short-term counseling, and referrals to appropriate community and private services. In situations where ongoing and long-term counseling is needed, ensuring costs are covered by health insurance plans with co-pay fees that are affordable for zoo staff and do not cause unnecessary financial burden is key and has important implications for fostering equitable access to mental health support services. Unfortunately, EAPs are often underutilized by employees (101, 102). A lack of knowledge about mental health and concomitant stigma toward mental health problems and help-seeking behavior often results in delays in seeking professional support via EAPs. Others may associate EAP programs as a resource for coping with personal rather than professional challenges (101). Sometimes the emotional energy resulting from moral distress or workplace trauma prohibits people from taking initial steps in seeking support (103). Increasing awareness about the opportunities available through EAPs and streamlining processes could decrease barriers to access. Brokering connections for zoo employees to counselors with expertise in zoo-related loss and grief may foster validation of grief responses and enhance POS. Future research is needed to establish rates of mental health stigma and attitudes toward help-seeking behavior among zoo professionals.

In this vein, it is also important for the zoo industry to recognize that zoo professionals' access to appropriate and timely services is further compounded by the scarcity of behavioral and mental health professionals. A 2022 survey of mental health practitioners conducted by the American Psychological Association found that 60% of psychologists reported no openings for new patients and more than 40% had a waiting list of 10 patients or more (104). Notably, the U.S. Department of Health and Human Services estimates a deficit of 10,000 mental health professionals by 2025

across the country, highlighting the urgent need for innovative approaches to promote mental health. Workplaces are increasingly recognized as effective places to promote mental health literacy programs and other health promotion activities (105). Mental health literacy refers to an individual's knowledge and beliefs about mental disorders, which aids in the recognition, management or prevention of mental health problems and reduces stigma about mental health and help-seeking. Not only is mental health literacy recognized as a method and tool for creating a mentally healthy and resilient organizational culture, but it is also increasingly recognized as an aspect of leader competency (106).

Given the increased risk for common mental health problems among ACHPs, improving mental health literacy in zoo leadership and people managers may support early identification of distress and related psychological health concerns among zoo staff and aid in facilitating help-seeking behavior. Specifically, standardized, psychoeducational programs that combat mental health problems and suicide may be effective models to employ in zoo settings. Curriculum programs such as Mental Health First Aid (MHFA), which teach program participants how to combat stigmatizing attitudes toward mental health, recognize acute mental health crises in others, and connect peers with helpful resources, may be particularly effective. MHFA has been adopted in more than 20 other countries around the world and has been evaluated in several studies, a majority of which have shown the MHFA program is effective in improving mental health knowledge, reducing stigmatizing attitudes, and increasing supportive behaviors (107).

Findings from this study elevate the need for both individual zoos and other organizations (e.g., AZA, Zoological Association of America, America Association of Zookeepers, World Association of Zoos and Aquariums) to advance practices regarding loss and grief surrounding animal deaths and transfers. Ideally, zoos would move towards cultures which promote open discussion of loss and grief and the integration of rituals prior to loss and into bereavement; thus, reducing disenfranchised grief responses. Despite differences in human and animal care settings, professionals who experience significant human loss can offer direction for creating proactive grief response cultures. Based on a study of occupational therapists' workplace bereavement experiences, Gilbert et al. (108) developed the C.A.R.E. Model of Employee Bereavement Support as a framework for organizations to respond to workplace loss and grief. The model incorporates four key components: (1) an emphasis on open, two-way *communication* about the loss; (2) the provision of *accommodations* to support employee's individual needs such as adapting work demands or hours; (3) *recognition* and acknowledgment of the impact of the loss at the individual and organizational level; and (4) offering *emotional support* such as empathic responses from managers, peers, or consumers.

As evidenced from this study's national sample of zoo employees and volunteers, rituals are negatively associated with burnout, depression, and anxiety. Fortunately, building grief rituals can be done with limited financial and human resources, providing opportunities for employees to invest in activities that feel meaningful in their healing. For example, in preparation for an anticipated loss due to transfer or death, allowing the space and time for employees to say "goodbye" to animals prior to the loss and participating in activities that foster a positive death experience may reduce negative grief reactions such as guilt about not being present for the animal at the end of life. However, circumstances surrounding death, including sudden deaths, staffing shortages, or individual comfort in leading grief rituals, may limit opportunities for pre-loss activities. In these situations, as with any animal death, opening spaces for celebration of life rituals, whether at regular team meetings or designated grief ceremonies, would promote the beneficial practice of continuing bond expressions such as sharing memories, photographs, or other meaningful objects (109–111). Preferably, organizations should allow for flexibility in their grief programming to support individual needs and be responsive to losses which may be experienced as traumatic, complicated, or occur in succession. Lastly, enhancing organizational grief resiliency skills through psychoeducation about loss and grief, including educational readings, webinars, or invited presentations by contracted grief counselors, could enhance individual and collective resilience and reduce the risk of complicated grief trajectories (112).

4.6 Limitations

Limitations of this study include that our survey was only available in the English language, and that we relied on a cross-sectional convenience sampling strategy. Furthermore, a majority of our sample identified as cisgender, white women. Although this finding is relatively consistent with publicly available demographic data on the zoo industry (113), because of this limited diversity, we did not have adequate statistical power to examine potential differences between or within racial and ethnic groups. Given evidence of disparities in mental health and access to mental health services between white and minoritized racial/ethnic groups (due to the impacts of systemic and structural racism on racialized population groups), as well as disproportionate rates of workplace discrimination and microaggressions experienced by marginalized individuals/communities, future research should explore variations in rates of burnout, mental health, POS and professional fulfillment across racial and ethnic identities within the zoo industry. It is important to understand whether there are racially-, ethnically-, and/or other identity-specific (sexual orientation, gender identity, disability, socioeconomic status) factors associated with these outcomes among zoo staff and volunteers. Such research could help to inform inclusive, culturally responsive interventions and promote equity in the workplace.

Other limitations of this study include that we did not assess cumulative animal losses within a specific period of time. Given the psychological impacts of complex (compounded) trauma, this is an important direction for future research. In addition, a limitation of our study is the potential lack of consistent methods used to recruit participants at other zoos. For example, it is possible that only ACHPs may have received the survey at some zoos, while participants of varying roles were recruited at others. In other

words, although our study was open to any zoo staff member or volunteer who had worked at their current zoo for 6 months, zoo leaders who assisted us with recruitment may have only sent the recruitment flyer to individuals or teams for whom animal loss was most relevant. This may have contributed to the large number of ACHPs and prevalence of recent animal loss in the current study. Relatedly, our utilization of AZA forums for recruitment may have contributed to bias in our sample; we are unable to determine how many individuals chose not to participate in our study and if there are any systematic differences in rates of participation across groups (e.g., avian vs. ungulate group forums). In addition, for participants who reported animal loss(es), we did not account for the length of their relationship with the animal or the animal's species or taxa in our analyses. Future research should test whether duration of the relationship and/or type of animal moderates the association between animal loss and the mental health outcomes explored in this study. It is possible that ACHPs who work with popular animals (e.g., mammals) have different experiences of animal loss than those who care for lesser-known or less "popular" animals due to varying levels of value placed on different species and taxa.

4.7 Conclusion

Our study provides compelling data indicating that the wellbeing of ACHPs in zoo settings is a significant concern with potential negative impacts on individuals, organizations, and animals under their care. Specifically, our findings suggest that ACHPs in zoos are struggling with disproportionate rates of burnout, anxiety, depression, and low rates of professional fulfilment and perceived organizational support. Zoos should develop organizational plans that foster a culture which normalizes and validates grief/loss experiences and is proactive in responding to animal loss, related trauma, and other occupational stressors. Building organizational resilience and offering opportunities for staff to develop adaptive coping and individual resiliency will be important actions in this effort. The results of this research sound the call for systemic changes within the zoo industry, for the betterment and welfare of both humans and the animals under their care.

Data availability statement

The datasets for this article are not publicly available due to concerns regarding participant anonymity. Requests to access the datasets should be directed to smcdonald@denverzoo.org.

Ethics statement

This study was approved by Colorado State University Institutional Review Board (IRB #4770). This study was conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants because the study was categorized as exempt by Colorado State University's Institutional Review Board. Because this was an anonymous survey, written informed consent was not required. An introductory statement explained the study and indicated to potential participants that consent was implied by completing the survey.

Author contributions

SM: Conceptualization, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. LK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. NN: Conceptualization, Data curation, Writing – review & editing. JC-M: Conceptualization, Writing – original draft, Writing – review & editing. RD-M: Data curation, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. Research reported in this publication was supported by the Denver Zoological Foundation (Denver Zoo).

Acknowledgments

We would like to thank our colleagues at Denver Zoo who provided support, advocacy, and/or other feedback for this project. In particular, we would like to acknowledge Erica Elvove, Elkin Alfred, Maura Davis, Dr. Jimmy Johnson, Emily Insalaco, Brian Aucone, and Jacque Taylor. We would also like to acknowledge the following organizations who assisted us in participant recruitment and/or provided other forms of support and encouragement for the project: Alabama Gulf Coast Zoo, ABQ BioPark, Audubon Zoo, Baton Rouge Zoo, Birmingham Zoo, Brevard Zoo, Busch Gardens, Cheyenne Mountain Zoo, Cleveland Metroparks Zoo, Detroit Zoo, Elm Wood Park Zoo, Folsom City Zoo Sanctuary, Fort Wayne Children's Zoo, Happy Hollow Park & Zoo, Henry Vilas Zoo, Honolulu Zoo, Lee Richardson Zoo, Little Rock Zoo, Louisville Zoo, Maryland Zoo, Miller Park Zoo, Milwaukee County Zoo, Philadelphia Zoo, Phoenix Zoo, Pittsburgh Zoo & Aquarium, Pueblo Zoo, Rolling Hills Zoo, Sacramento Zoo, Safari West, San Diego Zoo Wildlife Alliance, Santa Barbara Zoo, Sedgwick County Zoo, St. Louis Zoo, Tulsa Zoo, Turtle Back Zoo, Virginia Living Museum, Virginia Zoo, Wildlife Conservation Society, ZooAmerica North American Wildlife Park, Zoo Boise, Zoo Tampa at Lowry Park. Additionally, we thank Bella Shaw, the Zoo Scientist (Dr. Ricardo Lemos de Figueiredo), Companion Animals for Reform and Equity (Sloane Hawes), and the following groups and associated staff for their support: the American Association of Zookeepers, the Association of Minority Zoo and Aquarium Professionals, Growing Resilience in Aquarium and Zoo Professionals (GRAZE).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 26 April 2024
DOI 10.3389/fpsyt.2024.1406590

OPEN ACCESS

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RECEIVED 25 March 2024
ACCEPTED 15 April 2024
PUBLISHED 26 April 2024

CITATION
Wells DL and Treacy KR (2024) Pet attachment and owner personality. *Front. Psychiatry* 15:1406590. doi: 10.3389/fpsyt.2024.1406590

Pet attachment and owner personality

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Introduction: Research points to a relationship between owner personality and strength of attachment to one's pet, with implications for psychological health. So far, studies in this area, albeit sparse, have focused on the 'Big Five' traits of owner personality. The 'Dark Triad' is a cluster of traits that has also been linked to emotional deficits, but has been overlooked in relation to pet attachment. This study therefore examined the association between owner personality and pet attachment, focusing on both the 'Big Five' and 'Dark Triad' traits of personality.

Methods: A cross-sectional design was employed to collect quantitative data from dog and cat owners across the globe between May-June 2023. A purpose-designed online survey collected sociodemographic details, along with information on pet ownership, strength of the pet-owner bond and participant personality, assessed using the Big Five personality scale and the Short Dark Triad scale. The survey was fully completed by 759 dog and 179 cat owners.

Results: Analysis revealed significant correlations between many of the participants' personality traits, both within and between scales. Strength of pet attachment was positively correlated with neuroticism and conscientiousness, and, more weakly, to Machiavellianism. Regression analysis revealed that females, dog owners, people over the age of 50 and individuals who had children under 18 years to care for were more strongly attached to their pets than others. Both neuroticism and conscientiousness were found to be significant predictors of participants' pet attachment scores. None of the Dark Triad traits significantly predicted the criterion.

Discussion: This study points to a relationship between strength of attachment to one's pet and owner personality, at least as measured using the Big Five approach to personality assessment. There was little to support an association between the Dark Triad traits and strength of attachment to one's pet, although the link between these characteristics and attachment styles is still unknown. The investigation lends support for the idea that high attachment levels are associated with personality traits aligned to psychological ill-health. Further work is recommended in this area, with a greater focus on both strength and quality (e.g., attachment style) of the pet-owner bond.

KEYWORDS

attachment, big five, companion animals, dark triad, human-animal bond, mental health, personality, pets

1 Introduction

Pet ownership is a global phenomenon in today's society, with over 500 million pets residing in homes across the world (1). Figures show that in the United Kingdom alone, over 12 million dogs and 11 million cats were kept as pets in 2023, with incidence figures increasing on a yearly basis (2).

Although people keep pets for a myriad of reasons (e.g., companionship, recreation, protection), some acquire a companion animal in the belief that it offers health advantages [for reviews see (3, 4)]. Numerous studies have explored the widely held claim that 'pets are good for us', with some yielding positive results in this respect, particularly in relation to dog ownership [for review see (5)]. For example, pet ownership has been found to be negatively associated with depression in homeless youths (6), men infected with AIDS (7) and dog-owners living with HIV (8). The ownership of a pet, and again notably a dog, may also have a role to play in improving cardiovascular health, perhaps partly because of the increased exercise that typically accompanies the ownership of this species (9, 10). Whilst positive findings are widely published in the area, research does present a somewhat mixed picture, with some studies yielding either null results or pointing to some detrimental associations (11, 12). Amiot and colleagues (13), for instance, reported poorer mental health in pet owners than non-owners during the COVID-19 pandemic, while older Canadian pet owners were found to be less satisfied with their lives than non-pet owners (14).

One factor that may influence the extent to which an owner gains health benefits from their pet is the strength of the human-animal bond. Attachment theory was first proposed by Bowlby (15) to outline the child-caregiver relationship, but has since been used successfully to explain owner-pet relationships (16, 17), with studies suggesting that companion animals can serve as important attachment figures (18). One might expect a stronger attachment to one's companion animal to be associated with enhanced wellbeing, and, indeed, this is supported by some studies. Garrity and colleagues (19), for example, found lower levels of depression in older adults who reported higher attachment to their pets than more weakly bonded individuals. More recently, Teo and Thomas (20) reported that people who were "securely" attached to the animals in their care had lower levels of psychological distress and psychopathology and better quality of life than individuals less securely attached. Whilst perhaps counter-intuitive, some studies in this area have reported poorer mental health in people who are more strongly bonded with their pets. Wells and colleagues (21), for instance, found that higher bonds of attachment to one's dog or cat were associated with higher levels of depression, loneliness and lower levels of positive experience. Miltiades and Shearer (22) likewise found that higher levels of attachment to one's companion animal were associated with higher levels of depression in a group of older American adults, while Lass-Hennemann and associates (23) reported an association between stronger attachment to one's dog and higher levels of psychopathological symptoms. One explanation for these discrepant findings may lie with owner personality. Bagley and Gonsman (24), for example, found that people with 'Idealist' personality types had significantly higher pet attachment scores than 'Rationals' and 'Artisans'. Reevy and Delgado (25) likewise found a positive correlation between attachment to one's pet and neuroticism, a personality trait that has been linked to psychological health disorders, notably depression and anxiety (26–28). More recently, a study involving over 2,500 Finnish dog and cat owners reported that neuroticism and poor mental health are linked to 'anxious' attachment styles and highlighted the significance of individual personality traits in contributing to insecure attachment and, more generally, mental well-being (29).

So far, research exploring the association between owner personality and pet attachment has focused heavily on the 'Big Five' traits [openness to experience, extraversion, neuroticism, conscientiousness, agreeableness, (30)]. Different psychometric tests, however, measure different personality constructs and vary in their utility depending on the criterion under scrutiny (31). Other dimensions of personality are certainly worth focusing on, particularly those, like the 'Big Five', known to be linked to mental health. The following study therefore aimed to further explore the link between owner personality and pet attachment, focusing on both the Big Five traits of personality, and the 'Dark Triad', a cluster of traits [(Machievellianism, narcissism, psychopathy, (32)] that has been linked to emotional deficits (33) and has been sorely overlooked in relation to pet ownership and attachment. It was anticipated that the work would shed useful light on the link between owner personality and pet attachment, with important implications for its role in psychological well-being.

2 Materials and methods

2.1 Sampling and participants

Adult dog and cat owners from across the globe were invited to take part in this study via advertisements placed on social media platforms, e.g., Facebook, Twitter, Reddit. The advertisement indicated that the study was concerned with exploring pet-owner relationships, rather than drawing specific attention to its focus on attachment and personality assessment. The online survey attracted a total of 1487 responses. Following screening for inclusion criteria (provision of informed consent, dog/cat ownership, primary pet caregiver, aged 18+ years, proficiency in English) and quality of data (i.e., failure to complete the survey), 549 individuals were removed; the final dataset therefore comprised 938 eligible participants (for full details see Results).

2.2 Survey

A purpose-designed questionnaire was developed that aimed to collect information on sociodemographic background, pet ownership status, strength of the pet-owner bond and participant personality. Section 1 of the survey collected demographic information, including details on the respondents' gender (men, women, other), age (18-35, 36-50, 51+ years), geographic location (UK/Ireland, Americas, Europe, Oceania, Rest of World), marital status (single, married/co-habiting, separated/divorced, widowed) and whether or not they

cared for a child under 18 years of age (yes, no). This part of the survey also collected information on pet ownership. Respondents were required to indicate whether they owned a pet dog (yes, no) or cat (yes, no). If individuals owned more than one pet, they were asked to specify which animal (dog or cat) they would focus on for the survey. The survey also collected information on how long individuals had owned their pet (< 1 year, 1-5 years, >5 years).

The second part of the survey collected information on the participants' personality. Two validated psychometric tests were used:

i) *Big Five Personality Scale-Short* [BFI-S, (34)]. This is a 15-item questionnaire used to measure 5 aspects of personality (openness, conscientiousness, extraversion, agreeableness, and neuroticism). Participants are required to respond to a series of statements (e.g., "I see myself as someone who worries a lot") using a Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The scale has been shown to have good overall validity (34, 35).

ii) *Short Dark Triad* [SD3, (36)]. The SD3 is a 27-item questionnaire used to measure the 'Dark Triad' of personality traits (Machiavellianism, narcissism, and psychopathology). Respondents are asked to indicate their level of agreement with a series of statements (e.g., "It's not wise to share your secrets"), using a Likert scale ranging from 1 'strongly disagree to 5 'strongly agree'. The SD3 has good reliability and validity (36).

The final section of the survey (Section 3) collected information on owner-pet attachment. Participants were required to complete the *Lexington Attachment to Pets Scale* [*LAPS*, (37)], a test designed to determine the strength of the animal-owner bond. The LAPS requires owners to assess their degree of agreement with 23 statements (e.g., "I consider my pet to be a friend") on a 4-point Likert scale, ranging from 0 (strongly disagree) to 3 (strongly agree). The scale has been shown to have good internal consistency (coefficient alpha=0.928) and examines emotional attachment to both dogs and cats. The survey is one of the most commonly used indicators of owner-pet attachment in studies of the human-animal bond (21, 24, 25, 38).

2.3 Procedure

Pet owners interested in taking part in the study followed a link to the questionnaire hosted on the online platform Qualtrics. Here, they initially read the Participant Information Sheet, which gave details on what the study entailed. If still keen to take part in the investigation, participants indicated their consent by checking a box and commenced the survey. Individuals who did not meet the necessary inclusion criteria (see earlier) were not allowed to complete the consent form or go any further with the study. Following survey completion, participants were thanked for their time and allowed to read a debrief. The study remained open for one month between May-June 2023.

2.4 Data analysis

Simple descriptive statistics were initially carried out to explore the frequency and percentage of responses to the sociodemographic information. Pearson's moment correlations were subsequently conducted to assess any significant relationships between participants' personality trait scores (openness, conscientiousness, extraversion, agreeableness, neuroticism, Machiavellianism, narcissism, psychopathology), both within and between scales, and to explore for any associations with their attachment to pet (LAPS) scores. Finally, a linear regression analysis was conducted to examine whether any of the demographic variables or personality traits served as predictors of the strength of pet attachment. Overall LAPS score was set as the criterion variable, while factors of owner gender (men, women [none of the participants checked the 'other' category]), age (18-35, 36-50, 51+ years), geographic location (UK/Ireland, Americas, Europe, Oceania, Rest of World), marital status (single, married/co-habiting, separated/divorced, widowed), parental status (parent of child under 18, not parent of child under 18), pet type (dog, cat), length of pet ownership (<1year, 1-5 years, >5 years) and personality traits (openness, conscientiousness, etc.), were set as the predictor variables. The assumptions underlying regression analysis were sufficiently met. Inspection of scatterplots for the continuous predictors revealed linear relationships with the criterion variable. There was no evidence of any multicollinearity between the predictor variables (all variance inflation factor (VIF) values < 1.6; mean VIF=1.32, SD=016). Scatterplots revealed homoscedasticity of residuals, while Q-Q plots showed that the residuals followed a normal distribution.

2.5 Ethics

Full ethical approval for the study was granted by the University's Faculty Ethics Research Committee (EPS 23_174).

3 Results

3.1 Participants

Demographic information on the participants involved in the study can be found in Table 1. As can be seen, most of the participants were from the Global North (UK/Ireland, Europe or the Americas). The majority of respondents were women, under 50 years of age and were married or cohabiting. Just over half of the sample were parents to children under 18 years of age. The vast majority of the cohort reported owning a dog, with most people having cared for their pet for over one year.

3.2 Pet owner personality

Mean personality scores for both the BFI and Dark Triad scales are presented in Table 2. Analysis revealed a number of small, although statistically significant, correlations between many of the participants' personality traits (Table 3). All of the Dark Triad traits were positively correlated with each other. Significant correlations

TABLE 1 Number and percentage of participants according to demographic factor (*n=938*).

Demographic Factor	N	%
Gender		
Men	139	14.8
Women	799	85.2
Age (years)		
18-35	322	34.3
36-50	335	35.7
51+	281	30.0
Geographic location		
UK/Ireland	285	30.4
Americas	246	26.2
Europe	202	21.5
Oceania	108	11.5
Rest of World	97	10.4
Marital status		
Single	159	17.0
Married/cohabiting	715	76.1
Separated/divorced	54	5.8
Widowed	10	1.1
Parental Status		
Child < 18 years	484	51.6
No child <18 years	454	48.4
Pet ownership		
Dog	759	80.9
Cat	179	19.1
Length of pet ownership		
< 1 year	79	8.5
1-5 years	474	50.5
>5 years	385	41.0

were also found between many of the BFI trait scores. Specifically, neuroticism was negatively correlated with traits of extraversion, agreeableness and conscientiousness, while extraversion was found to be positively associated with openness and conscientiousness. Both openness and agreeableness were positively correlated with conscientiousness. A number of Dark Triad trait scores were significantly correlated with BFI scores. Machiavellianism was positively correlated with neuroticism, but negatively associated with traits of conscientiousness, extraversion and agreeableness. Narcissism was positively correlated with openness, conscientiousness and extraversion, but negatively associated with neuroticism. Finally, significant negative correlations were found between psychopathy and BFI traits of conscientiousness and agreeableness.

TABLE 2 Mean (SD) personality scale scores (*n=938*).

Personality Trait	Mean	SD
BFI		
Openness	4.20	0.81
Conscientiousness	4.01	0.84
Extraversion	3.19	1.21
Agreeableness	4.13	0.79
Neuroticism	3.09	1.10
Short Dark Triad		
Machiavellianism	1.84	0.01
Narcissism	1.69	0.01
Psychopathy	1.13	0.01

3.3 Personality and pet owner attachment

Three personality traits were significantly correlated with participants' LAPS scores, all in a positive direction: neuroticism, conscientiousness and, more weakly, Machiavellianism. None of the other personality traits were associated with owners' strength of attachment to their pets scores (Table 3).

A total of 938 cases were analysed for the linear regression model concerned with attachment level, which was found to be significantly reliable (R^2 = 0.37, F[22,937]=6.78, P<0.001). Gender, age, parental status and pet ownership status all served as significant predictors of participants' LAPS scores (Tables 4, 5). Women had significantly higher LAPs scores than men, respondents over the age of 50 years were more strongly attached to their pets than younger individuals, carers of children under the age of 18 years had higher scores than individuals without children in this age group, while dog owners were more strongly attached to their pets than cat owners.

Two of the personality traits served as significant, positive predictors of the criterion variable, namely neuroticism and conscientiousness. People higher in these traits were more strongly attached to their pets than individuals lower in these traits.

4 Discussion

This paper explored the relationship between strength of the human-animal bond and owner personality, with a focus, for the first time, on the Dark Triad of traits.

The results of this study showed significant, although modest, interrelationships between many of the participants' personality traits, both within and between scales. All of the Dark Triad traits were positively correlated with each other, a finding that concurs with other published work in this area (32, 39, 40). These close correlations have led some authors to question whether the Dark Triad traits are sufficiently distinct or harbour an element of conceptual redundancy (41); psychopathy, in particular, is considered by some authors to be indistinct from Machiavellianism (42, 43). Others have suggested that

TABLE 3 Pearson moment correlations between Big Five, Dark Triad and Lexington Attachment to Pets (LAPS) scores.

Trait	O	C	E	A	N	M	Nar	P	LAPS
O	-								
C	0.08*	-							
E	0.12***	0.09**	-						
A	0.02	0.21***	0.07*	-					
N	-0.04	-0.24***	-0.21***	-0.01***	-				
M	-0.001	-0.13***	-0.08**	-0.32***	0.12***	-			
Nar	0.22***	0.12***	0.46***	0.005	-0.23***	0.20***	-		
P	0.03	-0.14***	0.03	-0.44***	-0.02	0.41***	0.23***	-	
LAPS	0.04	0.13***	-0.01	0.002	0.11***	0.06*	0.05	0.05	-

O, openness to experience; C, conscientiousness; E, extraversion; A, agreeableness; N, neuroticism; M, Machiavellianism; Nar, narcissism; P, psychopathy; LAPS, Lexington Attachment to Pets. *P<0.05; **P<0.01; ***P<0.001.

TABLE 4 Results of the linear regression analysis for Lexington Attachment to Pets Scale scores involving predictor variables of participant gender, age, geographic location, marital status, parental status, type of pet owned, length of pet ownership, BFI and Dark Triad traits.

Predictor	Standardized β	95% CI	t	P
Gender				
Men (ref)				
Women	0.13	1.42-4.22	3.66	<0.001
Age (years)				
18-35 (ref)				
36-50	-0.02	-1.51-0.86	-0.55	0.58
51+	-0.13	-3.59- -0.94	-3.35	<0.001
Geographic location				
UK/Ireland (ref)				
Americas	0.01	-1.39-1.77	0.24	0.81
Europe	0.07	-1.31-4.12	1.01	0.31
Oceania	0.13	-0.11-6.56	1.89	0.06
Rest of World	0.12	-0.39-6.42	1.73	0.08
Marital status				
Single (ref)				
Married/cohabiting	0.009	-1.20-1.52	0.23	0.81
Separated/divorced	0.05	-0.71-4.07	1.38	0.17
Widowed	0.06	-0.43-9.28	1.79	0.07
Parental status				
No child <18 years (ref)				
Child <18 years	0.18	1.75-3.87	5.21	<0.001
Pet ownership				
Cat (ref)				
Dog	0.20	2.86-5.35	6.47	<0.001

(Continued)

TABLE 4 Continued

Predictor	Standardized β	95% CI	t	P
Length of pet ownership				
<1 year (ref)				
1-5 years	0.11	-0.07-3.48	1.88	0.06
>5 years	0.10	-0.24-0.07	1.71	0.09
Personality traits				
Openness	0.04	-0.07-0.34	1.31	0.19
Conscientiousness	0.15	0.26-0.67	4.49	<0.001
Extraversion	-0.04	-0.24-0.06	-1.13	0.26
Agreeableness	0.02	-0.17-0.28	0.48	0.63
Neuroticism	0.13	0.16-0.48	3.88	<0.001
Machiavellianism	0.04	-0.04-0.18	1.25	0.21
Narcissism	0.05	-0.04-0.21	1.36	0.17
Psychopathy	0.03	-0.07-0.18	0.90	0.37

we need to broaden our view of dark personality and instead of considering three traits as one construct, we should perhaps contemplate a construct that encompasses a wider range of 'dark' characteristics, e.g., perfectionism, spitefulness, greed (44, 45).

Many of the Big Five traits were also found to be significantly correlated with each other, with the direction of these associations largely in line with published work on personality. For example, neuroticism has been found to be robustly negatively correlated with traits of agreeableness, conscientiousness and extraversion, at least at the between-person level of analysis (see (46) for a discussion of this issue), and indeed a negative correlation between these variables was found in the current study. Likewise, as unearthed here, other authors have found a negative correlation between extroversion and neuroticism and a positive association with openness to experience (47).

Significant associations were found between some of the Big Five factors and Dark Triad traits. For example, Machiavellianism and psychopathy were negatively correlated with Big Five traits of conscientiousness and agreeableness. Narcissism, by contrast, was positively correlated with openness to experience, conscientiousness and extraversion, but negatively correlated with neuroticism. Other authors have reported correlations between the Dark Triad and the Big Five variables (48). Whilst findings have been somewhat inconsistent in relation to exactly which traits are correlated and the direction of these relationships, the current investigation largely aligns with this work (32, 40, 49).

The results from this study revealed positive correlations between people's attachment to pet scores (LAPS) and traits of neuroticism, conscientiousness and, to a weaker degree, Machiavellianism. Some of these personality traits are associated with poor mental health outcomes. Neuroticism, in particular, has been associated with the propensity to experience negative emotions, including sadness, anger, loneliness, anxiety and feelings of vulnerability (50, 51). People who score more highly for this trait are at greater risk from a wide variety of psychological disorders, including obsessive-compulsive disorder (OCD), bipolar disorder, major depression and schizophrenia [for review see (52)]. Machiavellianism, a trait found to be positively correlated with neuroticism in this study, albeit weakly, has also been linked with poorer mental health, reduced happiness, low self-esteem and higher levels of anxiety and depression (53–55). Whilst neuroticism and Machiavellianism could be considered disadvantageous traits from a mental health perspective, conscientiousness, by contrast, has typically been associated with benefits. People who score highly for this trait, for example, tend to have better physical and mental health, stronger relationships and greater longevity [for review see (56)].

The findings from the current investigation concur with previous work regarding the variables that predict strength of the pet-owner bond. Gender was found to be one of the strongest predictors of the criterion variable, with women being more closely attached to their pets than men, a finding that has been widely reported (21, 57, 58) and may be linked to women showing greater levels of empathy (59, 60). The current study also found a significant association between level of pet attachment and parental status, with people who had children under the age of 18 years to care for being more strongly attached to their pets than individuals without these responsibilities. Interestingly, Wells and colleagues (21) reported the opposite relationship to the findings presented here; their study, however, was conducted during a COVID-19 lockdown, when parents of young children were likely to have been busy trying to juggle working from home with homeschooling, perhaps leaving less time to invest in, or bond with, their pets. In accordance with other studies (21, 23, 61–63), dog owners were found to be more strongly attached to their pets than cat owners. This discrepancy in attachment may be related to the social nature of these animals, with dogs developing stronger bonds of attachment, particularly to humans (64, 65), than cats.

TABLE 5 Mean (SD) LAPS scores according to demographic factor.

Demographic Factor	Mean	SD
Gender		
Men	49.49	8.54
Women	51.72	7.71
Age (years)		
18-35	52.24	7.51
36-50	51.00	7.59
51+	50.89	8.52
Geographic location		
UK/Ireland	51.85	7.63
Americas	51.04	7.83
Europe	51.59	7.90
Oceania	51.86	8.23
Rest of World	50.02	8.15
Marital Status		
Single	51.98	7.86
Married/co-habiting	51.15	7.85
Separated/divorced	52.29	8.42
Widowed	54.50	5.42
Parental Status		
Parent of child <18	52.44	7.27
Not parent of child <18	50.27	8.33
Pet ownership		
Dog	52.17	7.55
Cat	48.13	8.38
Length of pet ownership		
<1 year	50.15	8.52
1-5 years	51.69	7.66
> 5 years	51.29	7.98

LAPS score range=19.0-65.0.

Unlike other companion animals, dogs are also more likely to respond to human emotions, even adapting their behaviour in response to their carers' emotional cues, thereby encouraging closer bonds of attachment (66).

Several authors have unearthed a positive correlation between pet owner attachment and poor mental health (21–23), leading one to question whether high attachment levels are associated with personality traits aligned to psychological ill-health. The results from the present investigation lend support for this, although other factors, including type of pet owned and parental status served as stronger predictors of strength of attachment than personality (see above). In relation to personality traits, however, higher levels of neuroticism, a trait known to be associated with poor mental health (see earlier), were associated with higher pet attachment scores. Interestingly, studies that have focused on the *nature* of the pet-owner bond (as opposed to the *strength* of the relationship, explored here) have shown that high levels of neuroticism are positively correlated with an 'anxious' style of attachment, i.e., one that reflects having worries about the pet being available, sensitive and/or responsive to the owner's needs (25, 29, 67). These types of thoughts and expectations have also been reported in inter-human attachments and are deemed somewhat maladaptive working models (68).

Both the present investigation, and other studies (25, 67), also found that conscientiousness positively predicted strength of pet attachment. This personality trait is typically associated with positive mental health outcomes (see earlier). That said, it is still unclear whether this trait is linked to adaptive or maladaptive attachment styles. For example, the trait has been found to be negatively correlated with both 'anxiety' and 'avoidance' styles of attachment (25, 67), hinting at a more functional type of relationship. However, Stahl and colleagues (29) recently found that more conscientious cat owners were more anxiously attached to their pets. Going forwards, it is recommended that further consideration is given to the potentially important relationship between strength of attachment to one's pet, attachment style and mental health. The results from both the present study and other investigations in this area show that people with different personality types may have similar strengths of attachment to their pets, but potentially different attachment styles that may differ in terms of their adaptivity.

One might have expected some of the Dark Triad traits to have served as significant predictors of people's strength of attachment to their pets, particularly considering the correlation (albeit modest) that was unearthed between Machiavellianism and LAPS scores. The Dark Triad has been associated with various indicators of parenting style, with authoritative parenting being negatively correlated with Dark Triad tendencies and authoritarian and detached parenting more positively correlated with these traits (69). Vonk and colleagues (70) also found that people who were high in grandiose narcissism [as assessed by the 'Pathological Narcissism Inventory, (71)] were more attached to their 'traditional' pets (e.g. dog, cat, hamster) than individuals lower in this trait (this correlation was not unearthed for owners of 'untraditional' pets, e.g. reptiles, amphibians, parrots). Of interest, the Dark Triad has been associated with both a general dislike of animals and animal cruelty (72); it may therefore be the case that people high on these personality traits are generally less likely to own animals, or to own them for different reasons, than individuals lower on these traits. Indeed, it has been argued that people with dark personalities may be more inclined to own exotic species [for financial gain and status, (73, 74)], animals not of focus in the current investigation. Of note, lower mean scores for all of the Dark Triad traits were found in the present study compared to other populations (36, 75); again, this could lend some support for the idea that people high in these traits are less likely to own pets and may also explain the lack of significant associations unearthed here (i.e., a floor effect).

Owner personality has important implications, not only for their own health, but that of their pets. Reevy and Delgado (25) found that a high level of neuroticism was associated with a high level of affection towards a pet and high anxious attachment, leading them to argue that neuroticism may offer benefits to a pet's welfare, with people high on this trait perhaps being more perceptive and responsive to changes in the animal's behaviour or health. Pet owners prone to this style of attachment do indeed report higher levels of caregiving and attentiveness to their animals (76). The impact of this on the psychological welfare of their animals, however, is very much open to debate. Indeed, neuroticism has been linked to the manifestation of various pet behaviour problems, including destructiveness, sexual mounting and owner-directed aggression (77). Gobbo and Zupan (78) found that dogs of more neurotic caregivers displayed more aggression, both towards conspecifics and humans, while Finka and associates (79) showed a link between higher owner neuroticism and an increased likelihood of cats having a behaviour problem. Together, these studies suggest that neuroticism may be a maladaptive personality trait, both for humans and their pets alike.

5 Limitations

Like other studies in this area, there are limitations to this investigation that must be acknowledged. Firstly, it is possible that the online recruitment method employed attracted a certain cohort of people, e.g., individuals who were overly attached to their companion animals. As with most, if not indeed all, studies in this area, the majority of the participants were women, a variable found to be associated with both companion animal attachment and mental well-being. Although challenging, it would be useful for future studies to focus more specifically on men, particularly in light of the difference in attachment styles that exist between the sexes (80, 81). Whilst the scale used to assess pet attachment (LAPS) in the present study is the most commonly employed in this area, a response bias leaning towards higher attachment (perhaps with participants feeling fearful of being perceived as 'unloving' of, or 'unbonded' to their pets) cannot be ruled out. Future studies may be able to address this by including additional, perhaps more objective, measures of pet attachment (e.g., recording frequency of physical contacts between owners and their pets, oxytocin levels, etc.) and exploring the relationship between these types of attachment tool. Although this study was concerned with exploring the link between pet-owner attachment and owner personality, the role of other variables must be considered. For example, Lass-Hennemann and colleagues (23) found that attachment to humans mediated the relationship between mental health and strength of attachment to one's dog. Future research needs to consider the wide variety of variables that may be associated with attachments and mental well-being beyond those considered here. Other studies have reported an influence of pet owner race, ethnicity, economic status, etc. (82), and the role of these demographic variables is worth exploring in future statistical models. This study also attracted participants from the global north, rendering it difficult to generalize findings beyond those reported here. Finally, it is worth remembering that this research focused purely on the strength of the owner-pet bond; further work is recommended in this area, with a greater focus on both strength and quality (i.e., attachment styles) of the pet-owner bond.

6 Conclusions

Overall, this study points to a relationship between strength of attachment to one's pet and owner personality, at least as assessed using the Big Five approach to personality measurement. There was little to support the idea that the Dark Triad traits were associated with strength of attachment to one's pet, although the link between these characteristics and attachment styles is still unknown. There are clearly important links between human-animal attachment and mental health outcomes, both for people and their pets. Developing scales that assess attachment relationships is therefore important from a One Health perspective. There may be benefits to moving beyond the two-dimensional models of human attachment (83) thus far employed in research on owners and their pets. Studies also need to explore, ideally using longitudinal approaches, directionality of attachment bonds and the degree of interdependence between traits of owners and their companion animals. Attachment theory points to a bidirectional relationship, with bonds shaped by both parties (84). Future studies may like to explore direction of causation to more fully understand the complex interactions between human and pet personality traits and the psychological health outcomes for both partners.

Data availability statement

The datasets presented in this article are not readily available because the dataset presented in this paper is considered confidential as consent for open access was not secured at the time of participant recruitment. Requests to access the datasets should be directed to d.wells@qub.ac.uk.

Ethics statement

The studies involving humans were approved by Queen's University Belfast Faculty Ethics Research Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

DW: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing – original draft,

Writing – review & editing. KT: Data curation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors would like to thank all of those individuals who took part in this study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 28 May 2024
DOI 10.3389/fpsyt.2024.1390212

OPEN ACCESS

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RECEIVED 22 February 2024
ACCEPTED 10 May 2024
PUBLISHED 28 May 2024

CITATION
Rankins EM, Quinn A, McKeever KH and Malinowski K (2024) Ground-based adaptive horsemanship lessons for veterans with post-traumatic stress disorder: a randomized controlled pilot study. *Front. Psychiatry* 15:1390212. doi: 10.3389/fpsyt.2024.1390212

Ground-based adaptive horsemanship lessons for veterans with post-traumatic stress disorder: a randomized controlled pilot study

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Introduction: Equine-assisted services (EAS) has received attention as a potential treatment strategy for post-traumatic stress disorder (PTSD), as existing literature indicates that symptoms may decrease following EAS. Relatively little is known about the mechanisms at play during lessons and if physiological measures are impacted. The objectives of this pilot study were to 1) explore the effects of adaptive horsemanship (AH) lessons on symptoms of PTSD, hormone concentrations, and social motor synchrony; 2) determine if physiological changes occur as veterans interact with horses; and 3) explore if the interaction between veteran and horse changes over the 8-week session.

Methods: Veterans with PTSD were randomly assigned to control (CON, n = 3) or AH (n = 6) groups for an 8-week period (clinical trial; NCT04850573; clinicaltrials.gov). Veterans completed the PTSD Checklist (PCL-5) and Brief Symptom Inventory (BSI) at pre-, post-, and 2- and 6-month follow-up time points. They also completed a social motor synchrony test (pendulum swinging) and blood draw at pre- and post-time points. In weeks 1, 4, and 8, blood samples were drawn at 0 min, 3 min, 5 min, 25 min, and 30 min during the 30-min AH lessons. Veterans completed the Human–Animal Interaction Scale (HAIS) after each lesson. Blood samples were assayed for plasma cortisol, epinephrine, norepinephrine, and oxytocin. Data were analyzed with repeated measure ANOVAs. Changes in PTSD symptoms from pre- to post-time point were analyzed with paired t-tests.

Results: Changes in PCL-5 scores tended to differ (p = 0.0989), and global BSI scores differed (p = 0.0266) between AH (–11.5 ± 5.5, mean ± SE; –0.5 ± 0.2) and CON (5.3 ± 5.4; 0.4 ± 0.2) groups. Social motor synchrony and hormone concentrations did not differ between groups or time points (p > 0.05). Cortisol, norepinephrine, and oxytocin concentrations did not differ across sessions (p > 0.05). Epinephrine concentrations tended (p = 0.0744) to decrease from week 1 to 4 of sessions. HAIS scores increased ($p \geq 0.0437$) in week 3 and remained elevated as compared to week 1.

Discussion: Participant recruitment was the greatest challenge. These preliminary results agree with the literature suggesting that EAS can reduce symptoms of PTSD.

10.3389/fpsyt.2024.1390212

KEYWORDS

PTSD, trauma, equine-assisted services, horse, veteran, cortisol, nervous system, oxytocin

1 Introduction

Post-traumatic stress disorder (PTSD) is characterized by changes in behavior and functioning that fall within four symptom clusters—re-experiencing, avoidance, cognition and mood, and arousal (1). These symptoms develop after exposure to a traumatic event such as threatened death, serious injury, or sexual violation (1). The US Department of Veterans Affairs (2) estimates that 11%–30% of US veterans experience PTSD (3). Current treatment options for PTSD include medication and therapies such as cognitive processing therapy (CPT) and eye movement, desensitization, and restructuring (EMDR). The current standard for treatment is considered therapy, and in recent years, medication prescription has declined (4). Dropout rates among veterans in therapy are high (5), which has led to an exploration of alternative and complementary treatment options for PTSD. Among these are equine-assisted services.

Equine-assisted services (EAS) is an umbrella term encompassing therapies incorporating horses, their movement, or their environment; adaptive horsemanship; and equine-assisted learning, which share the common goal of improving people's health and well-being through interactions with horses (6). Therapies that incorporate horses can include occupational therapy, physical therapy, speech language pathology, counseling, psychotherapy, and recreational therapy (6). In all these instances, the therapy must be provided by a licensed therapist who incorporates horses into their professional practice. Adaptive horsemanship is provided by a riding instructor or other equine professional, generally credentialled by a certifying organization. This category includes adaptive equestrian sport, adaptive or therapeutic riding, and ground-based horsemanship instruction (6). The common goal of these adaptive horsemanship activities is to further the participant's riding and horsemanship skills. Equine-assisted learning is the newest area of EAS and, thus, is slightly less well-defined than the other two areas (6). Programming in this area focuses on school-related skills and individual and organizational development.

A recent review on equine-assisted services for veterans with a history of trauma reported that the existing literature indicates veterans can benefit from this type of programming (7). The author also concluded that the field is in the early stages of scientific development with more studies needed. Studies that have investigated the impacts of equine-assisted services on veterans with PTSD have focused on psychotherapy or counseling incorporating horses and adaptive horsemanship, generally adaptive riding. Among veterans, PTSD symptoms as measured on self-report and clinician administered scales and related measures such as depression, quality of life, anxiety, and affect are reported to improve following psychotherapy or counseling incorporating horses (8–19) and adaptive horsemanship (20–26).

There have also been preliminary investigations into the effects of equine-assisted services on veterans' salivary cortisol, functional MRI (fMRI), heart rate, heart rate variability, respiration rate, and blood pressure (8, 9, 14, 20). These types of physiological and neural measures are of interest as they can be useful biomarkers and begin to elucidate potential mechanisms of change. Most of these studies have focused on taking measures at pre- and post-intervention time points leaving a lack of knowledge concerning the physiological responses occurring during lessons as veterans interact with the horses.

This type of knowledge can help further the development of theoretical models to explain mechanisms of change during equine-assisted services. Currently, there are several proposed theories and ideas for why equine-assisted services can be beneficial to individuals who have experienced trauma. These include self-determination theory, the horse–human relationship and the bonding that can occur between the two, enhanced engagement and therapeutic alliance during sessions, emotional and physiological mirroring, self-distancing through metaphor, and an opportunity for biophilia and mindfulness (7, 27).

The autonomic nervous system controls most of the body's autonomic functions such as blood circulation and digestion. There is a dynamic balance between the sympathetic and parasympathetic divisions of the autonomic nervous system. Increased sympathetic activation is associated with greater arousal (increased heart rate, norepinephrine, and epinephrine and decreased heart rate variability), whereas parasympathetic activation results in lowered arousal. The autonomic nervous system can be modulated by factors outside of arousal. Oxytocin has been implicated as one of these modulators and is released in response to positive social contact and bonding (28–30). The other endocrine system commonly used as a marker of stress is the hypothalamic–pituitary–adrenal (HPA) axis. Cortisol is the end product of this system and is elevated under conditions of acute and chronic stress.

Muscular tension, most often in the area of the jaw, neck, and shoulder, has also been proposed as a potential indicator of stress in humans (31–33). Its applicability in an applied setting has not been studied, and it may prove a useful, non-invasive tool for measuring stress when recordings are made using surface electromyography (sEMG).

Altered patterns of social functioning are a product of PTSD and can have major deleterious effects on an individual's homelife and integration into society (34). PTSD is often also co-morbid with major depressive disorder with similar events leading to an increased risk for both disorders (35). Co-regulation is altered in those with depression (36). Social motor synchrony is a readily measurable form of co-regulation in which the synchrony between gross motor movements is measured (36–38). Social motor synchrony is a potential marker of an individual's health and their ability to experience attunement or synchronization with those around them and thus could prove to be a relevant biomarker for those with PTSD (39).

Documenting and investigating the interactions between horse and human during equine-assisted services is needed, as the horse and its interactions with the human are key to these services. Therapist–client

alliance and human–horse bond have been shown to increase over 12 weeks of therapy but is unknown how soon this change occurs and if it remains consistent (11). Self-reports of interactions between human and animal, such as the Human–Animal Interaction Scale are one means of beginning to explore how the interactions between veterans and horses may change over the course of a session (40).

Based on the gaps in our current understanding of the effects of equine-assisted services on veterans with PTSD, four objectives for this pilot study were developed:

1) Determine the feasibility of recruiting, enrolling, and completing data collection with veterans with PTSD.
2) Explore the effects of adaptive horsemanship lessons on symptoms of PTSD, hormone concentrations, and social motor synchrony in combat veterans.
3) Determine if physiological changes occur as veterans interact with horses in weekly lessons.
4) Explore if the interaction between veteran and horse changes over the course of an 8-week session.

2 Materials and methods

Study procedures and materials were approved by the Rutgers University Institutional Review Board (Protocol No. 2019001999) and Institutional Animal Care and Use Committee (Protocol No. 999900214). Study procedures took place in Piscataway, NJ (pre-, post-, and follow-up measures) and Monroe Township, New Jersey (adaptive horsemanship lessons). The study was considered a clinical trial and registered (NCT04850573) at clinicaltrials.gov.

2.1 Study design

A randomized controlled design was used in which participants were randomly assigned to an 8-week wait-listed control (CON) or 8-week adaptive horsemanship (AH) condition.

2.2 Study conditions

2.2.1 Wait-listed control

The CON group continued their daily activities with no changes for the 8-week period and were offered 4 hours of adaptive horsemanship lessons after completing their post measures.

2.2.2 Adaptive horsemanship lessons

Veterans in the AH group participated in 30-min lessons once a week for 8 weeks with the same horse or pony (n=6). Horses and ponies had been selected and trained for work in equine-assisted services following Professional Association of Therapeutic Horsemanship, International (PATH Intl) guidelines. Horses and ponies continued to work in their regularly scheduled programming (adaptive riding, physical and occupational therapy integrating horses, and equine-assisted learning) outside of study activities. Horse behavior and physiology were monitored throughout the study, and no adverse effects were noted (see Rankins et al. (41) for a full description).

All lessons were taught and overseen by one individual who is certified by PATH Intl as an Equine Specialist in Mental Health and Learning (ESHML). In the first lesson, veterans were instructed on basic horse safety considerations (range of vision, approaching, and working around the horse), horse behavior (flight or fight response and prey animals), and grooming (standard grooming procedure including cleaning the hooves). Instruction was provided verbally, and then, the participant practiced skills such as approaching the horse and grooming with feedback as needed from the instructor.

Subsequent lessons began with the veteran grooming the horse. The horse was secured with a halter and lead line to a tie ring during all grooming. After grooming, the participant received direct instruction on a horsemanship skill (leading, leading with the horse at liberty in the arena, or long lining) or reviewed the previously introduced skill. The remainder of the lesson was allocated to allowing the participant to practice the skill with feedback from the instructor as needed to keep the horse and participant safe and allow them to progress. Within each skill, progression proceeded from performing the skill on straight lines and circles to obstacle courses with simple obstacles (ground poles, cones, and barrels). Not all veteran and horse pairs progressed through all skills, as progress was tailored to the individual.

2.3 Participants

Nine (30% of targeted enrollment of 30) male veterans between the ages of 18 and 75 who had been deployed and experienced combat completed data collection (Table 1). Potential participants with severe traumatic brain injury, an amputation, a diagnosis or experience of bi-polar disorder, schizophrenia, or substance dependence in the last 3 months or a pacemaker were excluded (Table 2).

An additional nine male non-veterans between the ages of 18 and 75 were enrolled to serve as the other half of the dyad in the social motor synchrony task in which pairs of participants swing a pendulum and the synchrony between pendulums is recorded (see *Section 2.5.1* for more details). Synchrony can only be measured in dyads, and the standard for this type of task is to use a healthy individual as the other part of the dyad (37, 38). Non-veterans were excluded if they had a chronic or acute mental or physical health issue or a pacemaker (Table 2). Dyads were pair-matched on the basis of age (non-veteran within ± 5 years of the veteran's age) and highest level of education completed following the methods of Varlet et al. (38).

2.4 Recruitment and screening

Potential participants were recruited from the surrounding area through word of mouth, distribution of flyers through the New Jersey Department of Military and Veteran Affairs, and radio

TABLE 1 Demographics of participants who completed all data collection procedures.

	Veteran Participants		Non-veteran Participants (n = 9)
	CON (n = 3)	AH (n = 6)	
Age	35 ± 6	38 ± 3	35 ± 3.5
Race			
White	3	5	7
Black/African American	0	1	1
Asian	0	0	1
Hispanic or Latino			
Yes	0	1	0
No	3	5	9
Education Level			
Associate's Degree	0	1	1
Some College	2	1	3
Bachelor's Degree	1	1	2
Master's Degree	0	3	3
Years of Military Service	12 ± 7	12 ± 4	Not applicable
Service Branch			
Army	1	4	Not applicable
Marine Corps	2	2	Not applicable
History of Traumatic Brain Injury			
No	0	6	Not applicable
Yes (mild or moderate)	3	0	Not applicable
Previous Experience with Horses			
No	2	4	Not applicable
Yes	1	2	Not applicable
Number of Medications	3.7 ± 3.7	2.5 ± 0.8	0.4 ± 0.4
Number of PTSD Treatments	1.3 ± 0.9	1.2 ± 0.3	Not applicable

Continuous data are presented as means ± SE. Categorical data are presented as counts.

advertisements. Those interested in participating (n = 79 veterans, n = 52 non-veterans; Figures 1, 2) contacted the study coordinator (EMR) to learn more and complete a pre-screening questionnaire over the phone to assess eligibility criteria (Table 1). Non-veterans meeting the eligibility criteria were placed on a waiting list until a veteran with whom they could be matched enrolled in the study.

If veterans met the eligibility criteria in the pre-screening questionnaire, they completed the informed consent process with the study coordinator and the Life Events Checklist (LEC-5) and

TABLE 2 Inclusion and exclusion criteria for veteran and non-veteran participants.

Criteria for Veterans		Criteria for Non-veterans	
Inclusion	Exclusion	Inclusion	Exclusion
• Male • Veteran of the United States Military • Deployment in a military combat zone and combat experience • 18–75 years of age	• Severe traumatic brain injury (TBI) • An amputation • A diagnosis or experience of bi-polar disorder, schizophrenia, or substance dependence in the previous 3 months. • A pacemaker	• Male • 18–75 years of age	• Service in the United States Military • A chronic mental or physical health issue • An acute mental or physical health issue in the previous 3 months • A pacemaker

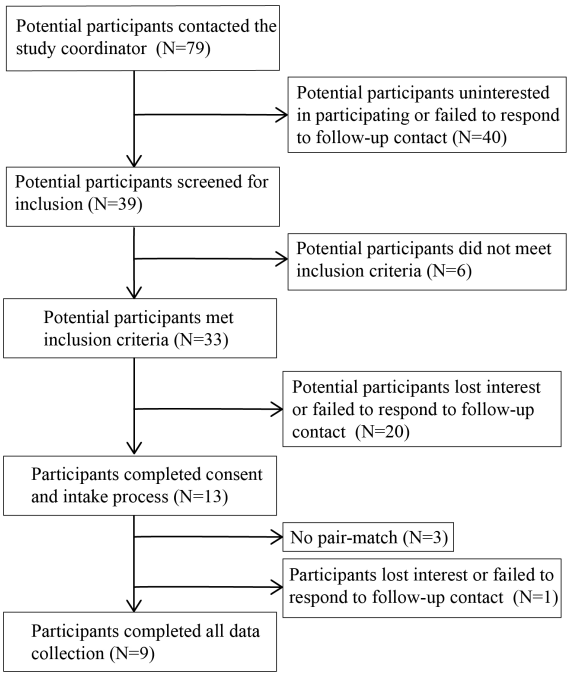

FIGURE 1
Flow diagram of number of veteran participants and their participation in study activities.

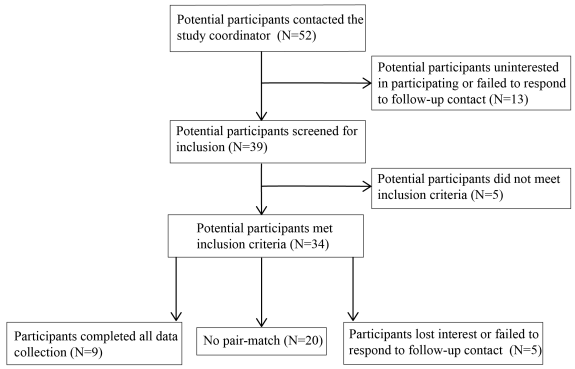

FIGURE 2
Flow diagram of number of non-veteran participants and their participation in study activities.

Clinician Administered PTSD Scale (CAPS-5) interview with a trained graduate student from the Rutgers University School of Applied and Professional Psychology (42–45). Students were overseen by a clinical psychologist. If students were unsure how to score an item given the information provided by the veteran, the issue was discussed with the clinical psychologist and a score agreed upon. Veterans meeting clinical cutoffs for PTSD on the past month version of the CAPS-5 (n= 13; Figure 1) were enrolled in the study.

2.5 Pre-, post-, and follow-up measures

Pre-measures were taken the week before veterans started the 8-week adaptive horsemanship (AH) program or CON period. Post-measures were taken the week following completion of the AH program or CON period. Follow-up measures were taken 2 and 6 months after completion of the AH program. At the pre-measure time point, non-veteran participants arrived 20 minutes before veteran participants to complete the informed consent process and provide demographic information. Only veteran participants completed the follow-up measures. Pre-measure procedures consisted of a social motor synchrony test, blood draw, and completion of the PTSD Checklist (PCL-5) and brief symptom inventory (BSI). These procedures were repeated at the post-measure time point, and veteran participants also completed a questionnaire on medication, treatment, and lifestyle changes. At the follow-up time points, only the PCL-5, BSI, and questionnaire on medication, treatment, and lifestyle changes were completed.

2.5.1 Social motor synchrony

Participants were seated in chairs (0.9 m apart) in a quiet room to complete the social motor synchrony test adapted from Fitzpatrick et al. (37). Each chair had a pendulum (54 cm length, 100 g weight) attached to it with a telemetric triaxial gyroscope (Ultium EMG, Noraxon, Scottsdale, AZ, USA) secured (3M, St. Paul, MN, USA) to the end of the pendulum. Data were recorded continuously and transmitted to a computer (Mobile Precision 3541, Dell®, Round Rock, TX, USA) for real-time monitoring. Markers denoting the start and end of each data collection phase were placed automatically by the software (myoMUSCLE™, Noraxon, Scottsdale, AZ, USA). Participants completed two tests: unintentional and intentional social motor synchrony. Unintentional social motor synchrony was assessed in a 90-s test where participants swung their pendulums at a self-selected, comfortable pace. Participants looked away from one another for the first 30 s, at one another for the middle 30 s, and away from one another for the final 30 s. This was repeated three times for three weight configurations: 1) veteran's weight in the middle and non-veteran at the bottom, 2) both weights at the bottom, and 3) veteran's weight at the bottom and non-veteran weight in the middle. Intentional social motor synchrony was assessed in a test consisting of 60 s of data collection followed by 30 s of rest and washout. In the rest and washout periods, participants could sit and rest. Participants swung their pendulums in an antiphase (pendulums at opposite points in the swinging arcs) and in-phase (pendulums at the same point in the swinging arcs) trials. Trials were repeated three times within each of the three pendulum weight configurations. Trial order was randomized across participants.

The first and last 10 s of each trial were removed before data analysis. The continuous relative phase time series of the data was calculated using the Hilbert transformation (37, 38, 46). The circular variance of continuous relative phase time series was calculated (MATLAB® 2022b; MathWorks, Natick, MA, USA) to determine synchrony between participants (47).

2.5.2 Blood draw and hormone assays

A registered nurse performed blood draws via antecubital fossa venipuncture (Vacutainer Safety-Lok blood collection set, 23 GA,

Becton, Dickinson and Company, Franklin Lakes, NJ, USA) after scrubbing the site with a 70% isopropyl alcohol solution and allowing it to air dry. Blood was drawn into lithium heparin-coated (2 mL) and EDTA-coated tubes (3 mL) and immediately placed on ice until centrifuged at 2,500 rpm for 5 min. Plasma was aliquoted into cryovials and stored at −80°C until assayed.

Plasma samples were thawed at room temperature (20°C–22°C) and assayed for cortisol (heparinized), oxytocin (EDTA), norepinephrine (EDTA), and epinephrine (EDTA) concentrations. Cortisol concentrations were determined using a competitive enzyme-linked immunosorbent assay (Cortisol ELISA, Enzo Life Sciences Inc., Farmingdale, NY, USA) validated for use in humans. A 1:16 dilution was used for all samples. The intraassay coefficient of variation was 2.9%, and the interassay coefficient of variation across three runs was 6.1%. Analytical sensitivity was 56.72 pg/mL. Epinephrine concentrations were determined using a competitive enzyme-linked immunosorbent assay (LDN®, Nordhorn, Germany) validated for use in humans. Plasma sample volumes were between 180 µL and 200 µL. The intraassay coefficient of variation was 4.4%, and the interassay coefficient of variation across four runs was 11.4%. Analytical sensitivity was 0.05 ng/mL. Norepinephrine concentrations were determined using a competitive enzyme-linked immunosorbent assay (LDN®, Nordhorn, Germany) validated for use in humans. Plasma sample volumes were between 180 µL and 200 µL. The intraassay coefficient of variation was 3.7%, and the interassay coefficient of variation across four runs was 10.6%. Analytical sensitivity was 0.02 ng/mL. Oxytocin concentrations were determined using a competitive enzyme-linked immunosorbent assay (Oxytocin ELISA, Enzo Life Sciences Inc., Farmingdale, NY, USA) validated for use in humans. A 1:8 dilution was used for all samples. The intraassay coefficient of variation was 2.3%, and the interassay coefficient of variation across three runs was 4.2%. Analytical sensitivity was 15.0 pg/mL. All hormone concentrations were calculated using an immunoassay software package (MARS Data Analysis Software v 3.20, BMG Labtech, Cary, New York) from a four-parameter logistic regression. Curve fit was high across all assays and runs ($R^2 \geq 0.99$).

2.5.3 PTSD symptoms

Veterans completed the PCL-5 and BSI, self-report measures to monitor the severity of current (past week) PTSD symptoms and psychological distress (48–51). A trained graduate student from the Rutgers University School of Applied and Professional Psychology scored all questionnaires.

2.6 Measures during adaptive horsemanship lessons

Data were also collected during the adaptive horsemanship lessons from the veterans enrolled in the adaptive horsemanship condition (n=6). Blood samples were drawn in weeks 1, 4, and 8. Surface electromyography (sEMG) and responses on the Human–Animal Interaction Scale were collected in weeks 1–8.

2.6.1 Blood samples and hormone assays

In weeks 1, 4, and 8, a registered nurse inserted an intravenous catheter (forearm or antecubital fossa, Insyte™ Autoguard™, 22 GA, 25 mm, Becton, Dickinson and Company, Franklin Lakes, NJ, USA) after scrubbing the site with a 70% isopropyl alcohol solution and allowing it to air dry. Catheters were placed at least 20 min prior to the start of the lesson. Blood samples were drawn into lithium heparin- (2 mL) and EDTA-coated tubes (3 mL) at 0 min (start of the lesson), 3 min, 5 min, 25 min, and 30 min (end of the lesson) into the lesson. Lines were flushed with a saline solution (0.9% NaCl) following each blood draw. Catheters were capped and covered with gauze in between blood draws to keep them clean. Samples were immediately placed on ice until centrifuged at 2,500 rpm for 5 min. Plasma was aliquoted into cryovials and stored at −80°C until assayed.

Plasma samples were thawed at room temperature (20°C–22°C) and assayed for cortisol (heparinized), oxytocin (EDTA), norepinephrine (EDTA), and epinephrine (EDTA) concentrations as described in *Section 2.5.2*.

2.6.2 Surface electromyography

Electrode attachment sites (right and left *masseter, sternocleidomastoid*, and upper *cervical trapezius*) were scrubbed with a 70% isopropyl alcohol solution and allowed to air dry. Electrodes (Ag/AgCl, 1.3 cm diameter, 2 cm inter-electrode distance, Noraxon, Scottsdale, AZ, USA) were placed parallel to the muscle fibers along the muscle belly approximately 2.5 cm above the mandibular angle (*masseter*), 3 cm below the earlobe (*sternocleidomastoid*), and along the line from the lateral edge of the acromion to the seventh cervical vertebrae (C7) (upper *cervical trapezius*) (52–54). Electrodes were attached to telemetric transmitter units (Ulitum, EMG, Noraxon, Scottsdale, AZ, USA), which were secured with self-adhesive backing (Noraxon, Scottsdale, AZ, USA).

Telemetric units connected wirelessly to a laptop (Mobile Precision 3541, Dell®, Round Rock, TX, USA) where data were viewed in real time and collected continuously (sampling frequency of 2,000 Hz, analog gain of 500, MR 3.14™, Noraxon, Scottsdale, AZ, USA). The data collected is a trace of electrical activity within the muscle of interest that reflects activation of the muscle fibers. Data collection only proceeded if impedance as measured by the software system was below 10 kΩ. As data were collected, a high-pass band filter of 10 Hz and a lowpass band filter of 500 Hz were applied to remove noise.

In post-processing, signals were filtered using a Butterworth filter (20 Hz cutoff) and rectified (MyoMUSCLE™, Norazon, Scottsdale, AZ, USA) (55). Peak amplitude over a 100-ms window during voluntary contraction in muscles of interest was used for normalization. Participants were instructed to clench their jaw, hold a shoulder shrug, and flex their neck to elicit muscular contraction. Signals were normalized to the peak value obtained in this period. Frequency content of the sEMG signal was determined using a Fast Fourier transformation (FFT) (MyoMuscle™, Noraxon, Scottsdale AZ, USA). The average rectified value (ARV, %) and median

frequency (MF, Hz) were calculated (MyoMuscle™, Noraxon, Scottsdale AZ, USA) for 100-ms periods at 2.5 min, 7.5 min, 12.5 min, 17.5 min, 22.5 min, and 27.5 min into the lesson as a measure of muscle activity during those time periods.

2.6.3 Human–Animal Interaction Scale

Veterans completed the Human–Animal Interaction Scale [(40) Qualtrics, Seattle, WA, USA] at the end of each lesson on a tablet (iPad mini 2, OS v12.5.4, Apple, Cupertino, CA). The 24-item scale was designed to describe and quantify human and animal behaviors during interaction with one another. The scale has high reliability and re-test reliability with acceptable validity (40). Responses were exported to a spreadsheet (Excel™, Microsoft, Redmond, WA, USA). The sum of undesirable human behaviors (two items) was subtracted from the sum of desirable human behaviors (12 items) to obtain the human subscore. The sum of undesirable animal behaviors (four items) was subtracted from the sum of desirable animal behaviors (six items) to obtain the animal subscore. The human and animal subscores were summed to obtain the total score.

2.7 Statistical analysis

Data were inspected for normality, and those violating the assumptions of normality were analyzed using an alternative distribution in the statistical model. The most appropriate models were selected using inspection of the residual plots and comparison of Akaike Information Criterion (AIC) values. Statistically different means in ANOVAs were separated using Tukey's method. Significance was set at $p < 0.05$.

Circular variance values from the test of social motor synchrony and hormone concentrations from pre- and post-measure time points were analyzed with a repeated measures mixed model ANOVA with fixed effects of time point, treatment, and their interaction and a random effect of participant (SAS 9.4, Cary, NC, USA). Time point was considered a repeated measure.

Changes in scores and subscores from the PCL-5 and BSI from pre- to post-measure time point were analyzed using an independent sample t-test with equal variance (SAS 9.4, Cary, NC, USA). Scores from the follow-ups (EAA group only) were analyzed with a repeated measures mixed model ANOVA with a fixed effect of time point and a random effect of participant.

ARV and MF of the sEMG signals were analyzed with a mixed model, repeated measures, lognormal distribution ANOVA with fixed effects of week, time point, side, and their interactions and a random effect of participant. Plasma hormone concentrations during the lessons were analyzed using mixed model, repeated measures ANOVAs with fixed effects of week, time point, and their interactions and a random effect of participant. Week and time point were considered repeated measures. Subscores and total scores from the Human–Animal Interaction Scale were analyzed using a mixed model, repeated measures ANOVA with a fixed effect of week and a random effect of participant.

3 Results

Nine veterans completed data collection with 100% attendance at pre- and post-measure data collections and adaptive horsemanship lessons. Three completed the wait-list control, and six completed the ground-based adaptive horsemanship lessons.

3.1 PTSD symptoms

The change in total scores from the PCL-5 and scores from the cluster of cognition and mood alteration symptoms (Cluster D) tended to differ between AH and CON groups with decreases in the AH group and increases in the CON group ($p = 0.0989$ and 0.0889) (Table 3). The change in global severity scores and somatization and psychoticism subscores from the BSI differed significantly between groups with scores decreasing in the AH group and increasing in the CON group ($p \leq 0.0488$) (Table 3). The change in depression, hostility, and paranoid ideation subscores from the BSI tended to differ between groups with scores decreasing in the AH group and increasing in the CON group ($p \leq 0.0721$).

Obsessive–compulsive, anxiety, and paranoid ideation subscores from the BSI were significantly lower ($p = 0.0414$, 0.0271, and 0.0456) in veterans in the AH group at 2 months post-intervention as compared to the pre-time point (Table 4).

3.2 Social motor synchrony

There were no significant differences ($p \geq 0.2151$) in circular variance across time points or groups (Figure 3).

3.3 Plasma hormone concentrations

There were no significant differences ($p \geq 0.1432$) in cortisol, epinephrine, norepinephrine, or oxytocin concentrations across pre- and post-measure time points or groups (Table 5).

During AH lessons, there were no significant differences ($p \geq 0.2748$) in cortisol, norepinephrine, or oxytocin concentrations across time points within lessons or weeks (Table 6). Epinephrine concentrations trended toward a statistically significant difference ($p = 0.0744$) in weeks 1 and 4 with concentrations being lower in week 4 (Table 6).

3.4 Muscle activity

There was a significant main effect of side ($p < 0.0001$) and side by week interaction ($p = 0.0209$) on ARV in the *masseter* (Table 7). ARVs were higher on the left than on the right side ($p < 0.0001$). ARVs were higher on the right side in week 1 than on the left side in weeks 4, 5, and 8 ($p \leq 0.0421$). ARV on the left side in week 1 was higher than on the right side ($p = 0.0023$). There were no significant differences in MF of the *masseter* (Table 8).

TABLE 3 Changes in PTSD symptoms from pre- to post-measure time points as measured on the PTSD Checklist (PCL-5) and Brief Symptom Inventory (BSI).

	Δ in Score from Pre- to Post-Measure		*p*-value
	CON (n = 3)	AH (n = 6)	
PCL-5	5.3 ± 5.4	−11.5 ± 5.5	*0.0989*
Reexperiencing	1 ± 1.7	−2.2 ± 1.4	0.2131
Avoidance	0.3 ± 1.7	−1.2 ± 0.4	0.2654
Cognition and Mood Alterations	3 ± 2.3	−5.5 ± 2.8	*0.0889*
Hyperarousal	1 ± 2.5	−4.3 ± 1.7	0.1203
Global BSI	0.4 ± 0.2	−0.5 ± 0.2	**0.0266**
Somatization	3 ± 0.6	−1.3 ± 1.2	**0.0488**
Obsessive Compulsive	2.7 ± 1.2	−2.8 ± 2.6	0.1801
Interpersonal Sensitivity	1 ± 1.5	−3.2 ± 1.8	0.1822
Depression	4.7 ± 3.3	−2.5 ± 1.6	*0.0579*
Anxiety	2 ± 1.7	−1.5 ± 1.6	0.2306
Hostility	3.3 ± 1.8	−3.8 ± 2.1	*0.0616*
Phobic Anxiety	0 ± 0	7.2 ± 7.5	0.5792
Paranoid Ideation	1.7 ± 0.7	−2.3 ± 1.3	*0.0721*
Psychoticism	2 ± 1.5	−4.7 ± 1.3	**0.0165**

Data are presented as means ± SEs. Bold font indicates a statistically significant difference between groups. Italic font indicates a trend toward statistically significant differences between groups.

TABLE 4 PTSD symptom severity as measured on the PTSD Checklist (PCL-5) and Brief Symptom Inventory (BSI) at pre-, post-, and follow-up measure time points in veterans in the adaptive horsemanship (AH) group.

	Pre	Post	2-Month Follow-up	6-Month Follow-up
PCL-5	51.8 ± 4.9	40.3 ± 8.7	43.3 ± 7.5	40.3 ± 6.9
Reexperiencing	11.2 ± 1.4	9.0 ± 2.1	9.3 ± 1.6	8.2 ± 1.4
Avoidance	5.5 ± 0.7	4.3 ± 0.7	4.8 ± 0.9	4.5 ± 1.2
Cognition and Mood Alterations	17.5 ± 3.1	12.0 ± 3.4	13.8 ± 3.3	13.7 ± 3.0
Hyperarousal	17.7 ± 1.8	13.3 ± 2.8	15.3 ± 2.5	14.0 ± 2.3
Global BSI	1.9 ± 0.3	1.5 ± 0.3	1.6 ± 0.4	1.7 ± 0.4
Somatization	8.8 ± 2.3	7.5 ± 2.9	6.5 ± 3.5	9.8 ± 3.9
Obsessive Compulsive	18.8 ± 2.0 ^{a}	16.7 ± 3.3 a^{b}	12.2 ± 3.4 ^{b}	13.3 ± 3.2^{a,b}
Interpersonal Sensitivity	7.8 ± 1.6	4.7 ± 1.3	4.0 ± 1.4	5.3 ± 2.2
Depression	12.7 ± 2.8	10.2 ± 3.4	9.3 ± 2.8	9.8 ± 3.5
Anxiety	11.0 ± 2.4^{a}	9.5 ± 2.6^{a,b}	6.7 ± 2.2^{b}	8.2 ± 2.3^{a,b}
Hostility	10.7 ± 2.0	6.8 ± 2.1	6.3 ± 1.9	9.5 ± 2.6
Phobic Anxiety	10.7 ± 1.5	8.8 ± 1.6	7.8 ± 2.2	8.7 ± 2.6
Paranoid Ideation	9.5 ± 1.3^{a}	7.2 ± 1.8^{a,b}	4.3 ± 1.5^{b}	6.5 ± 2.0^{a,b}
Psychoticism	10.7 ± 2.5^{a}	6.0 ± 1.6^{b}	6.5 ± 1.7^{a,b}	6.5 ± 1.9^{a,b}

Data are presented as means ± SEs. ^{a,b}Differing superscripts within a row indicate statistically significant differences ($p < 0.05$).

There were significant main effects of week ($p < 0.0001$) and side ($p = 0.0025$) and side by week interaction ($p = 0.0071$) on ARV in the *sternocleidomastoid* (Table 7). ARV in week 1 was lower than weeks 3, 4, and 8 ($p \leq 0.0067$). ARV in week 5 was lower than weeks 3, 4, and 8 ($p \leq 0.0236$). ARV in week 7 was lower than weeks 3 and 8 ($p = 0.0130$ and 0.007). ARV was lower on the right side than on the left ($p = 0.0025$). In week 1, ARVs were higher on the left side than on the right ($p = 0.0111$). ARV on the left side in week 5 was higher in weeks 3, 6, and 8 on the left side and week 8 on the right side ($p \leq 0.0436$). ARVs were higher on the left side in week 3 than the right side in weeks 1, 6 and 7 ($p \leq 0.0152$). ARV on the right in week 1 was lower than on the left side in weeks 4, 6, and 8 and on the right side in weeks 3, 4, and 8 ($p \leq 0.0034$). ARV on the left side in week 8 was higher than on the right side in weeks 6 and 7 ($p = 0.0454$ and 0.0449). There were no statistically significant differences in MF of the *sternocleidomastoid* (Table 8).

There was a significant main effect of week ($p < 0.0001$) on ARV in the *cervical trapezius* (Table 7). ARVs in week 8 were lower than in weeks 1, 3, 4, and 5 ($p \leq 0.0188$). ARV in week 3 were higher than in weeks 2 and 6 ($p = 0.0089$ and 0.0008). ARVs in week 5 were higher than week 6 ($p = 0.0170$). There were no statistically significant effects on MF in the *cervical trapezius* (Table 8).

3.5 Human–horse interaction

Human subscores on the Human–Animal Interaction Scale were higher in weeks 7 ($p = 0.0151$) and 8 ($p = 0.0013$) as compared to that in week 1. Animal subscores were higher in weeks 3 ($p = 0.0362$), 4 ($p = 0.0006$), and 7 ($p = 0.0059$) as compared to that in week 1. Total scores were higher ($p \leq 0.0437$) starting in week 3 and remained higher through week 8 as compared to week 1 scores (Figure 4).

4 Discussion

The objectives of the study were to 1) determine the feasibility of recruiting, enrolling, and completing data collection with veterans with PTSD; 2) explore the effects of adaptive horsemanship lessons on symptoms of PTSD, hormone concentrations, and social motor synchrony in combat veterans; 3) determine if physiological changes occur as veterans interact with horses in weekly lessons; and 4) explore if the interaction between veteran and horse changes over the course of an 8-week session. Only nine veterans completed data collection, indicating that the recruitment efforts and enrollment process should be modified. All data collection procedures were implemented without adverse effects, and the preliminary results support further investigation into equine-assisted services for veterans with PTSD.

4.1 Participant attrition

High rates of potential participant attrition occurred in this study with 84% of potential participants being lost or excluded from the study between initial contact and completion of informed consent. While higher than the attrition rate reported by Fisher et al. (12) in their study of equine-assisted psychotherapy for veterans with PTSD (66%), it would seem that a high rate of attrition is to be expected in these types of studies, particularly if attrition rate is calculated from initial contact. In the present study, this high attrition rate contributes to the low number of participants completing data collection, which is a severe limitation and makes this a pilot study. High attrition rates and low therapy session attendance are a common problem plaguing research involving human participants (5, 56). Attrition rates in the current

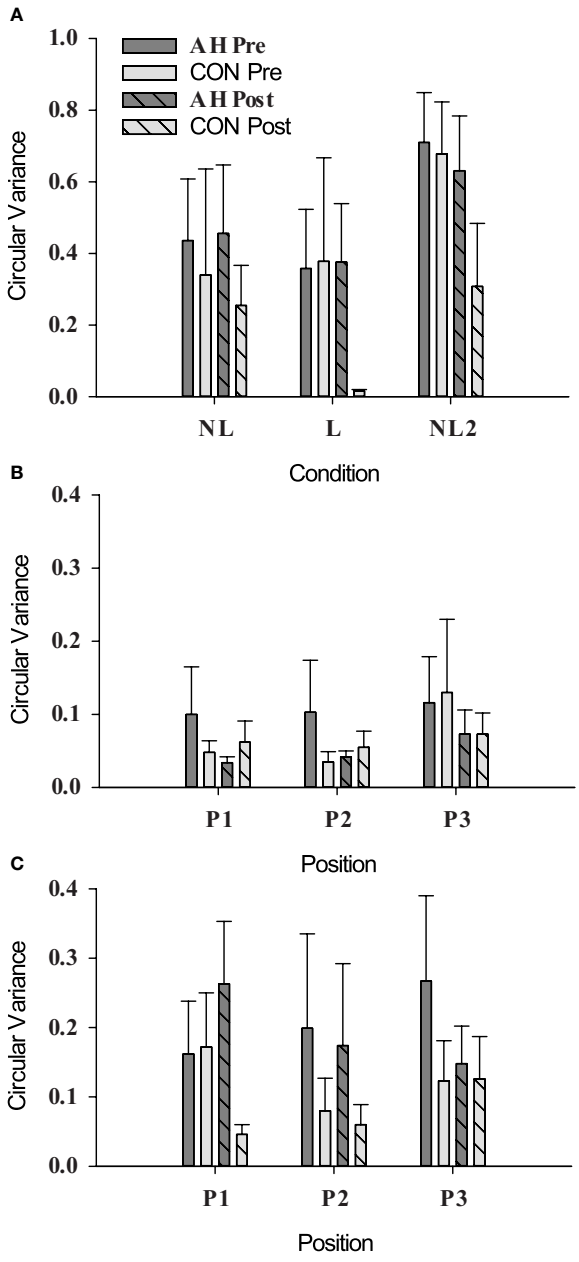

FIGURE 3
Circular variance as measured during social motor synchrony tests under **(A)** unintentional (NL, not looking; L, looking), **(B)** intentional in-phase (position refers to pendulum position, see *Section 2.5.1*), and **(C)** intentional antiphase conditions in AH and CON groups at pre- and post-measure time points. Data are presented as means ± SEs.

TABLE 5 Plasma hormone concentrations in veterans enrolled in the AH and CON groups at pre- and post-measure time points.

	AH (n = 6)		CON (n = 3)	
	Pre	Post	Pre	Post
Cortsiol (μg/dL)	3.79 ± 1.26	1.95 ± 0.47	1.54 ± 0.44	1.23 ± 0.44
Epinephrine (ng/mL)	0.08 ± 0.03	0.05 ± 0.01	0.04 ± 0.01	0.05 ± 0.01
Norepinephrine (ng/mL)	0.43 ± 0.06	0.44 ± 0.06	0.29 ± 0.02	0.43 ± 0.10
Oxytocin (μg/mL)	0.07 ± 0.01	0.06 ± 0.01	0.04 ± 0.01	0.04 ± 0.00

Data are presented as means ± SEs.

study were further complicated by the need for pair-matched control participants. Researchers planning to work with human participants, particularly this population of veterans with PTSD, need to account for these high attrition rates in their study design and recruitment efforts. While some participants were lost after completing the informed consent process, no participants were lost after starting the AH intervention. This is a promising finding given the high rates of dropout associated with traditional therapies for veterans with PTSD and has been corroborated by other researchers (5, 13).

The high attrition rate observed in the beginning stages of the enrollment process may have been compounded by using the CAPS-5 to determine PTSD diagnosis and eligibility for enrollment in the study. Anecdotally, some potential participants had previously received a PTSD diagnosis but failed to meet the criteria for a past-month diagnosis of PTSD using the CAPS-5 at the time of potential enrollment in the study. This discrepancy could be due to a multitude of factors including a diminishment of symptoms since the previous diagnosis, differences in diagnostic criteria, and underreporting of symptoms during the enrollment process. In the future, researchers may want to consider using the lifetime CAPS-5 instead of the past month CAPS-5 or accepting external proof of past PTSD diagnosis to help combat high attrition. Low enrollment in this study was the primary challenge in conducting the study.

4.2 PTSD symptoms

The decrease in depression, hostility, and paranoid ideation as measured on the BSI and the tendency for cognition and mood altering symptoms as measured on the PCL-5, and somatization, and

TABLE 6 Plasma hormone concentrations in veterans during AH lessons.

	Time Point	Cortsiol (μg/dL)	Epinephrine (ng/mL)	Norepinephrine (ng/mL)	Oxytocin (μg/mL)
Week 1					
	0 min	6.57 ± 2.42	0.11 ± 0.03	0.63 ± 0.16	0.07 ± 0.01
	3 min	5.02 ± 0.92	0.07 ± 0.02	0.59 ± 0.14	0.07 ± 0.01
	5 min	5.22 ± 0.87	0.08 ± 0.02	0.66 ± 0.12	0.08 ± 0.02
	25 min	4.70 ± 1.18	0.09 ± 0.03	0.64 ± 0.14	0.07 ± 0.01
	30 min	3.75 ± 0.77	0.11 ± 0.03	0.56 ± 0.08	0.08 ± 0.02
Week 4					
	0 min	5.72 ± 2.32	0.05 ± 0.01	0.83 ± 0.10	0.07 ± 0.02
	3 min	7.53 ± 2.83	0.05 ± 0.01	0.94 ± 0.12	0.06 ± 0.01
	5 min	3.63 ± 0.56	0.05 ± 0.01	0.91 ± 0.12	0.07 ± 0.02
	25 min	4.23 ± 1.06	0.06 ± 0.01	0.83 ± 0.10	0.07 ± 0.01
	30 min	3.63 ± 0.95	0.06 ± 0.02	0.80 ± 0.11	0.08 ± 0.02
Week 8					
	0 min	2.72 ± 0.55	0.06 ± 0.01	0.76 ± 0.13	0.06 ± 0.01
	3 min	5.94 ± 2.39	0.05 ± 0.01	0.79 ± 0.19	0.06 ± 0.01
	5 min	5.72 ± 3.25	0.06 ± 0.01	0.80 ± 0.13	0.08 ± 0.02
	25 min	4.09 ± 1.72	0.06 ± 0.01	0.79 ± 0.11	0.07 ± 0.01
	30 min	3.62 ± 1.44	0.09 ± 0.02	1.03 ± 0.22	0.06 ± 0.01

Data are presented as means ± SEs.

TABLE 7 Average rectified values (ARV) from the *masseter*, *sternocleidomastoid*, and *cervical trapezius* muscles.

	Masseter		*Sternocleidomastoid*		*Cervical Trapezius*	
Week	Left	Right	Left	Right	Left	Right
1	13 ± 3^{a}	9 ± 3^{b}	$32 \pm 14^{b,y,z}$	$15 \pm 5^{a,y}$	24 ± 5	23 ± 7
2	7 ± 1	6 ± 2	$13 \pm 2^{y,z}$	$12 \pm 2^{y,z}$	15 ± 3	14 ± 3
3	6 ± 1	6 ± 1	25 ± 4^{y}	19 ± 4^{z}	68 ± 31	89 ± 33
4	9 ± 2	5 ± 1	$20 \pm 2^{y,z}$	26 ± 5^{z}	48 ± 16	37 ± 12
5	9 ± 2	6 ± 1	46 ± 30^{z}	$25 \pm 15^{y,z}$	20 ± 5	19 ± 3
6	7 ± 2	7 ± 2	33 ± 11^{y}	$14 \pm 3^{y,z}$	27 ± 11	13 ± 3
7	12 ± 6	8 ± 2	$29 \pm 13^{y,z}$	$11 \pm 2^{y,z}$	21 ± 9	57 ± 18
8	7 ± 1	7 ± 2	35 ± 11^{y}	37 ± 12^{z}	6 ± 1	8 ± 2

Data are presented as means ± SEs. ^{a,b}Values within a row with differing superscripts are significantly different ($p < 0.05$). ^{y,z}Values within a column with differing superscripts are significantly different ($p \leq 0.05$).

psychoticism as measured on the BSI, and overall scores on both instruments to decrease are in line with outcomes reported in other studies, which also reported decreases in PTSD symptoms following various forms of equine-assisted services (8–13, 21). Variation (SE) in scores for PTSD symptoms in the current study was numerically higher than that reported by Malinowski et al. (8) and closer to that reported in the other studies. This is likely due to the time frame of the studies as the study of Malinowski et al. (8) occurred over 5 days and the other studies occurred over periods of weeks as did this study. With the exception of Malinowski et al. (8), these studies only reported overall scores on the PCL-5 or PTSD Checklist—Military Version (PCL-M), although all reported significant decreases in PCL-5 or PCL-M scores. Malinowski et al. (8) reported significant decreases in overall scores on both the PCL-5 and BSI. Hyperarousal symptoms were the only category of symptoms on the PCL-5, which showed significant reductions, while all symptom subcategories except for phobic anxiety and interpersonal sensitivity on the BSI showed significant decreases in the study of Malinowski et al. (8). The disparity in symptom clusters or subcategories showing change across studies is worth investigating further. Different types of equine-assisted services may be more or less effective in addressing particular clusters of symptoms, as the two studies in question employed different approaches—adaptive horsemanship lessons vs. psychotherapy integrating horses. While the changes seen in the current study are insufficient to guide treatment decisions, they do support continued investigation of equine-assisted services as a treatment for PTSD.

Studies by Arnon et al. (13), Fisher et al. (12), Lanning et al. (22, 26), and Marchand et al. (24) have reported data from follow-up times points ranging from 30 days to 3 months after the intervention. Except for Arnon et al. (13), these studies reported persistence of symptom reduction at the follow-up time point. In the current study, obsessive–compulsive, anxiety, and paranoid ideation subscores on the BSI were lower at the 2-month follow-up than at the pre-intervention time point. The preliminary results obtained in the current study and results from other studies reporting data from follow-up time points lead us to suggest that future studies should include measurements at follow-up time points to more closely track how symptoms change during the period following cessation of the activity or therapy. This is valuable

TABLE 8 Median frequency (MF) from the *masseter*, *sternocleidomastoid*, and *cervical trapezius* muscles.

	Masseter		*Sternocleidomastoid*		*Cervical Trapezius*	
Week	Left	Right	Left	Right	Left	Right
1	8 ± 1	8 ± 1	7 ± 1	7 ± 1	8 ± 1	9 ± 1
2	7 ± 1	9 ± 1	10 ± 1	9 ± 1	7 ± 1	6 ± 1
3	8 ± 1	11 ± 2	8 ± 1	8 ± 1	8 ± 1	9 ± 1
4	9 ± 1	8 ± 1	8 ± 1	10 ± 2	9 ± 1	9 ± 1
5	10 ± 2	8 ± 1	10 ± 1	9 ± 1	8 ± 1	8 ± 1
6	8 ± 1	8 ± 1	7 ± 1	8 ± 1	8 ± 1	9 ± 1
7	7 ± 1	11 ± 2	8 ± 1	8 ± 1	8 ± 1	9 ± 1
8	9 ± 1	10 ± 1	8 ± 1	8 ± 1	8 ± 1	8 ± 1

Data are presented as means ± SEs.

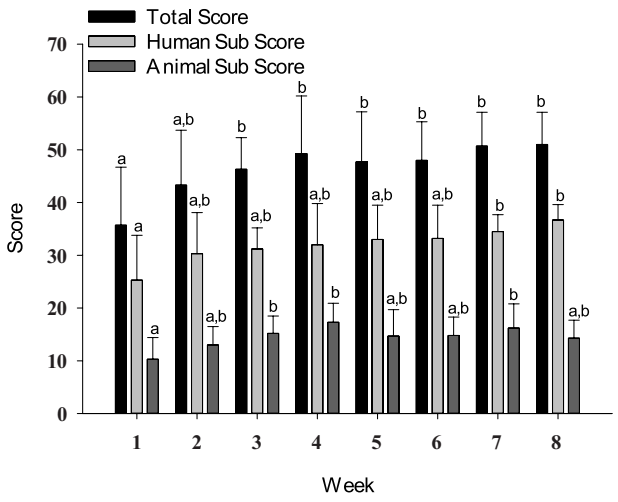

FIGURE 4
Total score, human subscore, and animal subscore from the Human–Animal Interaction Scale. Data are presented as means ± SEs. Differing superscripts indicate statistically significant differences.

information for providers and clinicians to guide their decisions about intervention duration and cessation.

4.3 Social motor synchrony

A circular variance value of 1 represents perfect synchrony, and a value of 0 represents no synchrony. Overall, circular variance was lower than values reported in other studies (37, 38). The reason for this discrepancy is unclear and may have contributed to the lack of differences observed at pre- and post-measurement time points. It should be noted that similarly low values were also obtained from a group of veterans without PTSD (57). While researchers may wish to explore this measure further in future studies, the difficulty of locating pair-matched individuals for the dyadic task limits the feasibility of this measure.

4.4 Hormone concentrations

All values for cortisol, epinephrine, and norepinephrine concentrations during all measurement time points fell within or only slightly above normal reference ranges for these hormones (58). Plasma oxytocin concentrations were similar to those reported by authors using the same quantification methods; however, there is debate over the accuracy of these quantification methods (59). Dilution recommendations provided by the manufacturer of the ELISA kit were followed. The lack of change in basal plasma hormone concentrations (cortisol, epinephrine, norepinephrine, and oxytocin) is likely related to the fact that these hormone concentrations were within normal ranges at the beginning of the study and did not differ significantly from the healthy participants and could be confounded by the small sample size (57).

Oxytocin, cortisol, and norepinephrine plasma concentrations remained relatively stable across session timepoints and weeks in the veterans. As this is the first study to have measured these hormones in this population during sessions, comparison among studies is impossible. The social bonding at play during humans' interactions with dogs that leads to increases in oxytocin concentrations may not be present in human–horse interactions, although further work is needed to confirm this hypothesis (60, 61). The response of the hypothalamic–pituitary–adrenal (HPA) axis also appeared to be unaffected by veterans' interactions with horses, as no changes in cortisol concentrations were found. Responses of the autonomic nervous system are not as straightforward, as no changes in norepinephrine concentrations were found, but epinephrine tended to decrease between weeks 1 and 4. High concentrations of epinephrine in week 1 and the subsequent decrease lead us to suggest that veterans experienced a shift toward sympathetic activation in the autonomic nervous system during week 1 and that in later weeks, the balance shifted toward parasympathetic activation. Given that anxiety and heightened arousal, especially in unfamiliar situations, is a component of PTSD, it would seem reasonable to expect veterans to experience these types of responses in entering an unfamiliar environment with novel expectations (62, 63). Given the small sample size, these are preliminary results and should only be used in guiding the development of future research studies.

Previous research has failed to find links between salivary and plasma catecholamines, making salivary measurement of these hormones scientifically unsound (64, 65). Thus, if researchers wish to continue pursuing this line of investigation, blood sampling will be needed. The sampling procedures (catheter) used in this study resulted in no adverse events, and no participants voiced concern over the procedures. The samples were quickly drawn with the veteran seated during the procedure. While further spacing between sample time points would be recommended; in this population, the procedure was feasible to implement. The fact that all participants were adults and a small sample was taken at each time point contributed to the feasibility of the blood draws. Additionally, a registered nurse with extensive experience in conducting blood draws for research studies was employed for these procedures and contributed to the success of the blood draws.

4.5 Muscle activity

Changes in ARV in the *sternocleidomastoid* and *cervical trapezius* muscles are likely an artifact of the veterans' movements during the lessons, as EMG traces for these muscles were visually observed to change with the veteran's movement and activity during live monitoring of data collection. These same patterns were not visually apparent in the EMG trace of the *masseter*. Results should still be interpreted with caution as recordings occurred during anisometric, dynamic movements rather than the isometric, static movements usually used for robust interpretation of results (66). ARV values in the current study were lower than those generally reported in the literature (67, 68). It should be borne in mind, however, that most research using EMG measures report results from targeted, specific activities or movements, whereas the current study included data from periods of relatively low activity when low muscle activation would be expected. Measuring sEMG as a potential marker of stress via muscle tension in an applied context seems unlikely to be useful given the results of this study.

4.6 Human–horse interaction

This study is the first known report of using the Human–Animal Interaction Scale with horses, as it was developed with other animal species (40). The increases in overall scores starting in week 3 were expected as Wharton et al. (11) also reported increases in client–therapist and client–horse relationships following psychotherapy incorporating horses. The Human–Animal Bond Scale used by Wharton et al. (11) had not been validated, however. The increase in scores in the present study indicates more positive human–horse interactions, as higher scores on the Human–Animal Interaction Scale are indicative of more positive behaviors, fewer negative behaviors, or both (40). The changes in horse subscores and total scores did not appear to be related to measurable behavioral changes in the horses, as no differences in horse behavior were found (41). The behavioral measures used in this study did not account for affiliative behaviors, though, which would be included in the Human–Animal Interaction Scale. Future studies should look at behavior and scores on instruments like the Human–Animal Interaction Scale, as there may also be differences in self-report and researcher reported measures as perception can become a confounding variable. In making decisions about which instrument to use, researchers should carefully consider whether the scale incorporates human behavior, animal behavior, or both. It may be useful to develop a scale specific to horse–human interactions, as behavior does vary across species.

4.7 Conclusion

The preliminary results of this pilot study support the need for further research addressing the outcomes of equine-assisted services for veterans with PTSD. The results from this small pilot study contribute to the literature that reports positive outcomes in terms of symptom severity following equine-assisted services. It also demonstrates the feasibility of collecting physiological data, such as hormone concentrations, during lessons without adverse effects for the participants. Recruitment was the greatest challenge in this study, and researchers planning to pursue this line of research should carefully plan to mitigate this challenge.

Data availability statement

The datasets presented in this article are not readily available because: Participants did not provide consent for sharing of data during the informed consent process. Requests to access the datasets should be directed to ellen.rankins@colostate.edu.

Ethics statement

The studies involving humans were approved by Rutgers University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The animal studies were approved by Rutgers University Institutional Animal Care and Use Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this study.

Author contributions

ER: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Visualization, Writing – original draft. AQ: Methodology, Resources, Supervision, Writing – review & editing. KHM: Conceptualization, Methodology, Supervision, Writing – review & editing. KM: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was funded by the Rutgers Equine Science Center, the State of New Jersey, and Boehringer Ingelheim. The funders had no role in designing the experiment, data analysis, or the decision to submit for publication.

Acknowledgments

We would like to extend our thanks to the staff and horses at Special Strides and the graduate students at the Rutgers University Graduate School of Applied and Professional Psychology for their help with the study procedures. This work was published in a dissertation (57) by the Rutgers University School of Graduate Studies.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Original Research
PUBLISHED 03 September 2024
DOI 10.3389/fpsyt.2024.1401222

OPEN ACCESS

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RECEIVED 14 March 2024
ACCEPTED 13 August 2024
PUBLISHED 03 September 2024

CITATION
Peters BC, Gabriels RL, Schmid AA, Pan Z, Merritt T, Hoffman A and Hepburn S (2024) The feasibility of occupational therapy using Zones of Regulation™ Concepts in an equine environment.
Front. Psychiatry 15:1401222.
doi: 10.3389/fpsyt.2024.1401222

The feasibility of occupational therapy using Zones of Regulation™ Concepts in an equine environment

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Introduction: The current paper aimed to assess the feasibility of a modified intervention protocol named "Occupational Therapy using Zones of Regulation Concepts in an Equine Environment" (OT-ZOR Equine).

Methods: A single arm A-B feasibility study was conducted, involving 14 autistic youth ages 6-13 years who first received 10-weeks of occupational therapy without horses (OT-ZOR Clinic) followed by 10-weeks of OT-ZOR Equine.

Results: All participants completed the study and attended 95% of OT-ZOR Equine sessions. Occupational therapists maintained 91% fidelity to the OT-ZOR Equine intervention protocol and there were no serious adverse events. All participants' caregivers and study occupational therapists rated being satisfied or very satisfied with the OT-ZOR Equine intervention. Youth demonstrated improved self-regulation following participation in the OT-ZOR Clinic and OT-ZOR Equine interventions. However, participants' social functioning only improved after OT-ZOR Equine.

Discussion: This study demonstrated that OT-ZOR Equine is feasible to implement, acceptable to recipients and providers, and may offer additive benefits in social functioning compared to occupational therapy intervention without horses. The current study provides a foundation for future efficacy research aimed at quantifying additive benefits of integrating horses into occupational therapy for autistic youth.

KEYWORDS

occupational therapy, hippotherapy, equine-assisted services, autism, feasibility

1 Introduction

Autism is defined by deficits in social communication and by the presence of restricted or repetitive patterns of behavior (1). Individuals on the autism spectrum [referred to henceforth as "autistic" (2)] often have unique strengths, such as strengths in visual perceptual tasks, certain aspects of auditory processing, or above-average performance in specific skills (e.g., memory, reading, drawing, music, etc.) (3, 4). Despite these strengths, many autistic individuals have difficulty with self-regulation, defined as the ability to monitor, evaluate, and modify one's arousal levels, emotional states, and behavior in order to execute goal-oriented actions (5, 6). Impaired self-regulation is believed to be inherent in autism, as evidenced by difficulty managing emotions (7), heightened physiological reactivity to daily activities (8, 9), and increased irritability, hyperactivity, aggression, elopement, and self-injury (10, 11). Impaired self-regulation in autistic youth can impact their daily living and quality of life, as evidenced by increased anxiety (12), poor social adjustment (13), and decreased academic performance (14).

Human-animal interaction, particularly with horses, appears to improve self-regulation in autistic youth (15). Two reviews of studies of animal-assisted interventions for autistic youth published 2012-2015 (16) and 2016-2020 (17) found that across different types of animal-assisted interventions, studies often found decreased problematic behaviors, increased positive emotions, and decreased physiological and behavioral indicators of stress (16).

One widespread application of human-animal interaction for autistic youth is equine-assisted services, an umbrella term for services that incorporate horses in order to benefit human health and wellbeing (18). There are over 700 centers across the US that provide equine-assisted services, and autism is consistently identified as the population most often served at these centers (19). One type of equine-assisted service, adaptive riding, is a recreational service focused on teaching horsemanship skills to individuals with disabilities; adaptive riding has been demonstrated to improve self-regulation and social outcomes in autistic youth (15). The beneficial effects of interacting with horses in a recreational setting provides a strong foundation for the notion that including horses in therapy services may lead to more efficacious therapy. However, very little is known about the efficacy of integrating horses into occupational therapy for autistic youth (20). Existing research is scarce and lacks standardized intervention protocols (21–24) and active comparison groups (21, 22, 24). This knowledge gap results in scant empirical information to guide occupational therapy and creates barriers to access services, as many payers do not reimburse for occupational therapy that integrates horses. Consequently, there is a critical need to establish how to best integrate horses into occupational therapy for autistic youth, and empirically demonstrate the additive benefit horses may have on therapy outcomes.

To fill this gap, our team embarked upon a program of research focused on developing and empirically evaluating occupational therapy integrating horses for autistic youth. We have previously developed an occupational therapy protocol named OT^{ee} HORSPLAY (Occupational Therapy in an Equine Environment: Harnessing Occupation for Self-regulation, Social Skills, and Play). Further described in a separate paper (25), OTee HORSPLAY integrated best practices in occupational therapy for autistic youth (26) (individualized goals, social skills training, activity-based intervention, integrations of strengths and interests, scaffolding, and multi-sensory activities) with purposeful inclusion of horses in the intervention to optimize youth's engagement. In particular, intervention development was guided by the hypothesized principles that 1) the movement of the horse, adjusted as needed by the therapist, can help optimize the youth's physiological arousal and behavioral regulation during the session, 2) interacting with horses can be motivating for many children, enhancing youths' attention and engagement in the therapy session, and 3) activities with horses can serve as powerful positive reinforcement for attempting new skills.

In a previous feasibility study we demonstrated that OT^{ee} HORSPLAY improved self-regulation and social outcomes in autistic youth (25) and was largely feasible to implement (27), but also identified several areas of further development needed prior to readiness for large-scale efficacy testing. Namely, OT^{ee} HORSPLAY broadly addressed self-regulation skills, social skills, *or* play skills; the priority area of intervention was determined during an occupational therapy evaluation. The broad nature of OT^{ee} HORSPLAY addressing three distinct goal areas led to large variability in the way the intervention was delivered, and therefore variable outcomes among participants. Thus, we determined there was a need for further standardization of the OT^{ee} HORSPLAY intervention protocol to allow for more uniform delivery across occupational therapists, while still allowing for individualization. Furthermore, our previous feasibility study identified a need to develop a feasible control group for the non-animal elements of OT^{ee} HORSPLAY (i.e. occupational therapy without horses).

1.1 Modifications to previously manualized intervention protocol

To address these needs, our team made major modifications to the intervention and study protocols, illustrated in Figure 1. First, to further standardize the OT^{ee} HORSPLAY manual we created two different modules: social play and self-regulation. Within each module, we also created two tracks: a track for participants with verbally fluent language, and a track for less verbal participants. In the current study, we asked caregivers to select either the self-regulation or social play module; the study team then assigned the child to a track within that module based on verbal fluency. Importantly, most caregivers selected the self-regulation module and were assigned to the verbally fluent track. *Therefore, this paper reports on occupational therapy in an equine environment addressing self-regulation skills in autistic youth who are verbally fluent.*

In creating the self-regulation module of occupational therapy in an equine environment, we chose to integrate concepts from the Zones of Regulation™ curriculum into the intervention manual. Developed by an occupational therapist, the Zones of Regulation™ curriculum teaches youth to recognize emotions in others and in themselves, categorize emotions into 4 different "zones", and use "tools" to regulate their emotions. The resulting intervention

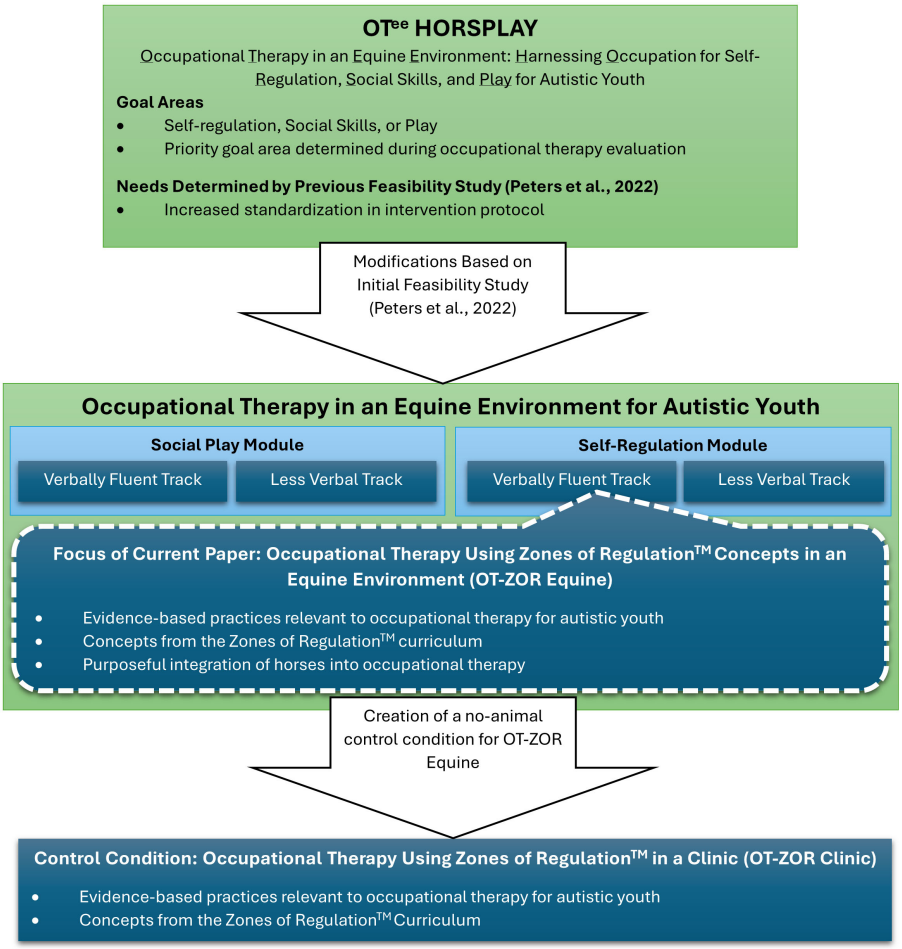

FIGURE 1
Situation of the current feasibility paper within the larger program of research.

protocol therefore integrates 1) evidence-based practices relevant to occupational therapy for autistic youth, 2) concepts from the Zones of Regulation curriculum, and 3) purposeful integration of horses into occupational therapy. We've named this intervention protocol Occupational Therapy using Zones of Regulation in an Equine Environment (OT-ZOR Equine).

Next, our team developed a control condition for all non-animal elements of OT-ZOR Equine, called Occupational Therapy using Zones of Regulation in a Clinic (OT-ZOR Clinic). This control condition combines evidence-based practices in occupational therapy with concepts from the Zones of Regulation curriculum (28).

1.2 Purpose and specific aims

Newly developed interventions should be assessed for feasibility prior to being evaluated for efficacy (29). Feasibility studies address the question "Can it work?" considering the following aspects: participant recruitment, intervention implementation and fidelity, intervention acceptability and adherence, data collection procedures, and preliminary participant outcomes (30). During the process of feasibility testing, investigators are encouraged to "refine their intervention through iterative development and then test the feasibility of their final approach" (31). Therefore, after further revisions guided by our previous feasibility study (27), we conducted a new study to assess the feasibility of OT-ZOR Clinic and OT-ZOR Equine. A separate paper reports on the feasibility of the new control condition, OT-ZOR Clinic (28). The current paper's purpose is to report on the feasibility of the OT-ZOR Equine intervention. Specifically, we aimed to evaluate: 1) participant recruitment, retention, and attendance, 2) intervention fidelity, safety, and caregiver assessment completion, 3) acceptability of the OT-ZOR Equine intervention to providing occupational therapists and caregivers of autistic youth, and 4) preliminary participant outcomes after the OT-ZOR Equine intervention.

2 Methods

2.1 Design

We implemented a single-arm A-B feasibility study (not randomized), where all youth first participated in ten weeks of

OT-ZOR Clinic, immediately followed by 10 weeks of OT-ZOR Equine. Outcome measures were completed at three time points: 1) pre-test, 2) after 10 weeks of OT-ZOR Clinic, and 3) after 10 weeks of OT-ZOR Equine. We also collected feasibility and acceptability data throughout the study. This design allowed us to test the feasibility of both OT-ZOR Clinic and OT-ZOR Equine in all participants, to prepare for a future study focused on efficacy. Peters et al. (28) reports feasibility of the OT-ZOR Clinic condition; this paper reports on the feasibility of the OT-ZOR Equine condition.

2.2 Participants

We distributed IRB-approved electronic flyers to community organizations to recruit autistic youth and their caregivers. Flyers advertised that youth would participate in both 10 weeks of occupational therapy in a clinic and 10 weeks of occupational therapy in an equine environment. Table 1 lists participant inclusion and exclusion criteria, and Figure 2 illustrates participants' progression through the study. Youth were first screened for inclusion in occupational therapy in a clinic through a two-part process that included 1) an online survey and 2) virtual screening visit using Microsoft Teams due to the Covid-19 pandemic. Twenty autistic youth and their caregivers were enrolled in the study. Consistent with other autism intervention feasibility studies (32–35), we chose a sample of 20 to allow for participant variability on the feasibility indicators defined below. Of the original 20 participants, 14 met additional inclusion criteria for the verbally-fluent self-regulation module (Figure 1; Table 1) and therefore received OT-ZOR Clinic followed by OT-ZOR Equine, the focus of this paper. After completing 10 weeks of OT-ZOR Clinic, youth were screened for inclusion in the second half of the study by participating in an additional screening visit for occupational therapy in an equine environment (Table 1); all youth met criteria and were included in the next 10 weeks of OT-ZOR Equine. This paper therefore focuses on the 14 participants who completed OT-ZOR Clinic and then OT-ZOR Equine.

2.3 Pre-intervention initial visit

The first study visit involved an occupational therapy evaluation and goal setting with an occupational therapist. The occupational therapy evaluation consisted of a) an occupational profile addressing youth's self-regulation, play, social participation, and education, and b) a 10-item self-regulation skill checklist with skills related to emotional awareness and use of self-regulation strategies. Next, the caregiver and therapist collaboratively set three individual goals related to three different self-regulation areas: understanding emotions, identifying self-regulation tools, and using self-regulation tools. Youth were invited to participate in this collaborative goal setting to the extent that they were able, unless the caregiver specifically requested not to involve youth in goal-setting due to self-esteem. After the first visit, the occupational therapist scaled goals using goal-attainment scaling methods described below.

2.4 OT-ZOR clinic intervention

Peters et al. (28) provides a thorough description of the OT-ZOR Clinic intervention, summarized here. OT-ZOR occurred in a private clinic playroom that included several swings, a rock-climbing wall, individual trampoline, scooter boards, a table and chairs, social turn-taking games, and general therapy supplies such as cones, beanbags, and bolsters. Two licensed and registered occupational therapists provided the OT-ZOR Clinic intervention. One occupational therapist had been licensed for three years, had experience providing occupational therapy to autistic youth, and was previously familiar with the Zones of Regulation curriculum. The other occupational therapist had been licensed for six years, had experience providing occupational therapy to autistic youth,

TABLE 1 Participant inclusion and exclusion criteria.

Original Inclusion Criteria	Original Exclusion Criteria
1. Age 6 – 13 years old 2. Score ≥ 11 on the SCQ 3. Diagnosed with ASD by a community provider 4. Meet clinical cut-offs for ASD on the ADOS on diagnostic report OR confirmed social-communication impairments during virtual screening visit (adaptation made for social distancing) 5. Able to follow 1-step directions 6. Score >10 on the irritability subscale of the ABC-C 7. Meet symptom criterion score on CASI-5 for mood, anxiety, or ADHD diagnosis	1. Rode a horse for 5 hours or more in the last 6 months 2. Weigh more than 200 pounds. 3. Planning on starting any intensive new therapies during the 1-year study period.
Additional Inclusion Criteria for Zones of Regulation Module	
8. Caregiver selected self-regulation as intervention priority 9. Verbally fluent as defined by ADOS-2 module 3 criteria	
Additional Inclusion Criteria for Equine Environment	
10. Meet PATH, Intl medical and behavioral standards, including obtaining a physician signature 11. Can ride a horse for 10 minutes while following safety rules	

ASD, Autism Spectrum Disorder; ADOS-2, Autism Diagnostic Observation Schedule, Second Edition; ABC-C, Aberrant Behavior Checklist, Community; CASI-5, Child and Adolescent Symptom Inventory, Fifth Edition; PATH Intl, Professional Association of Therapeutic Horsemanship, International.

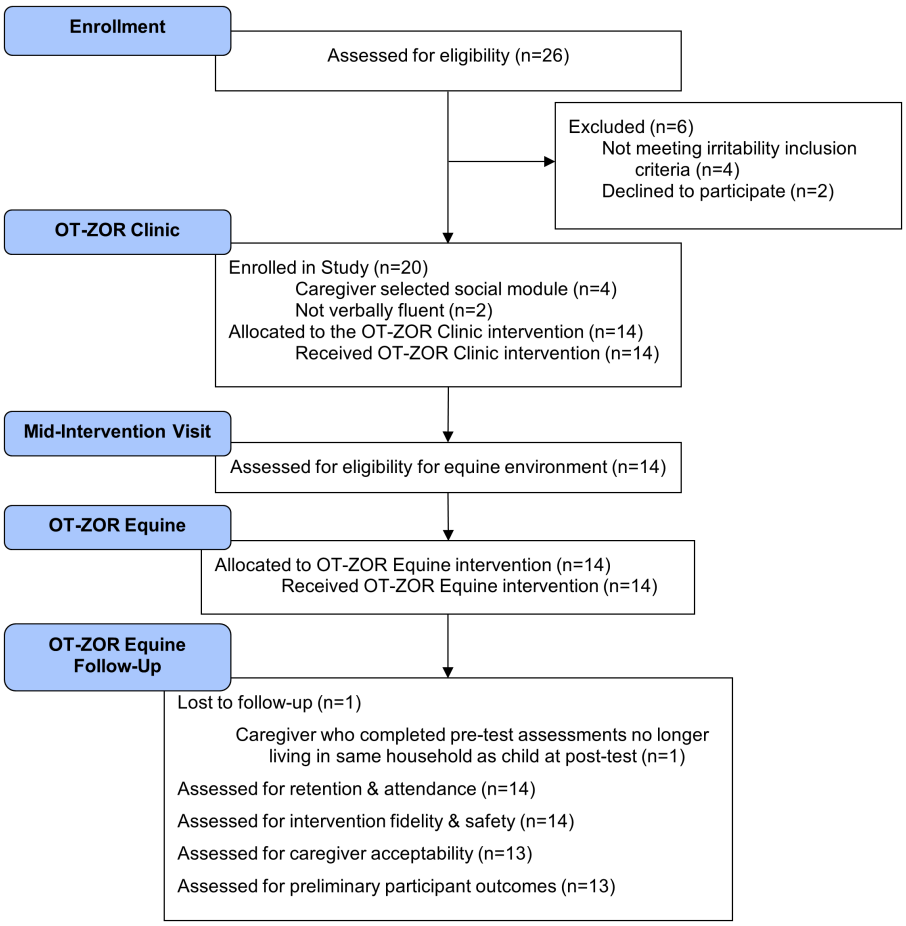

FIGURE 2
Modified CONSORT Diagram. OT-ZOR Clinic=Occupational Therapy using Zones of Regulation™ Concepts in a Clinic; OT-ZOR Equine=Occupational Therapy using Zones of Regulation™ Concepts in an Equine Environment. Adapted from "CONSORT 2010 Statement: Extension to Randomized Pilot and Feasibility Trials" by S. Eldridge, C. Chan, M. Campbell, C. Bond, S. Hopewell, L. Thabane, and G. Lancaster, 2016, BMJ, 355, p. 20.

but had limited previous exposure to the Zones of Regulation curriculum. Each therapist received 10 hours of training specific to the OT-ZOR Clinic manual and participated in five one-hour case conferences throughout both 10-week intervention sessions. Case conferences focused on ensuring fidelity to the intervention manual and identifying methods to address participant-related challenges.

The first author paired autistic youth into dyads after the initial pre-intervention visit based on social communication and self-regulation abilities. Each of these two participants was assigned their own occupational therapist, attempting to pair children with the same occupational therapist who performed the pre-intervention visit when scheduling allowed. Paired youth received therapy in the same space at the same time, which allowed youth to practice emerging skills with a social partner. Dyads attended ten weekly 60-minute sessions of occupational therapy in a clinic that followed a general structure: greeting, activities in a playroom, parent debrief, and goodbyes. The OT-ZOR Clinic manual includes 10 activities adapted from the original Zones of Regulation™ (36) curriculum, each activity addressing one of the following self-regulation skills:

- Categorizing emotions and alertness states into four Zones
- Recognizing emotions in facial expressions
- Identifying expected Zones for different situations
- Identifying body cues for different Zones
- Identifying individualized triggers
- Identifying sensory regulation tools
- Identifying calming regulation tools
- Identifying cognitive regulation tools
- Creating an individualized regulation toolbox, and
- Using an individualized regulation toolbox

These original Zones of Regulation™ activities were modified for an outpatient occupational therapy context and to fulfill critical elements of OT-ZOR Clinic in Table 2. For example, to work on the first skill of categorizing emotions and alertness states into four zones, the occupational therapists taught youth about the blue,

green, yellow, and red zones (Table 2 element #2- direct instruction). Next youth played a game by pulling a card with an emotion on it and acting out the emotion; the other child guessed the emotion and corresponding zone (element #3- therapeutic play activity). Youth then rode scooters to a poster that corresponded with the zone color and taped the emotion onto the poster (element 4- positive reinforcement using preferred activity). Throughout the activity the occupational therapists integrated children's strengths and interests (element #1), and scaffolded their ability to categorize them emotion into a zone (element #5). While joint activities were planned for every session (barring an absence), the level of engagement between youth varied based on youth's social abilities and social interest.

2.5 Mid-intervention visit

After 10 weeks of OT-ZOR Clinic, youth attended an additional visit (Figure 2) to ensure they met additional inclusion criteria for the equine environment listed in Table 1. This screening portion included riding a horse for 15 minutes while following safety rules. Then, caregivers and youth collaborated with the occupational therapist to update or set new goals for 10 weeks of OT-ZOR Equine.

2.6 OT-ZOR Equine intervention

The OT-ZOR Equine intervention occurred in a large indoor arena meant specifically for equine-assisted services, with available toys such as beanbags, cones, balls, a ring "tree" and rings, basketball hoop, mailbox, and poles. The intervention was provided by two licensed and registered occupational therapists. One occupational therapist had been licensed for 15 years and the other for 6 years. Both had Level 2 training from the American Hippotherapy Association, were also PATH Intl registered instructors, and had experience delivering occupational therapy in an equine environment to autistic youth. One therapist had prior experience using the Zones of Regulation curriculum, while the other had only limited prior exposure to the curriculum. These therapists were different therapists than those who provided the OT-ZOR Clinic intervention. Therapists received 10 hours of training specific to the OT-ZOR Equine manual and participated in five one-hour case conferences throughout both 10-week intervention sessions.

TABLE 2 Critical intervention elements.

OT-ZOR Equine	OT-ZOR Clinic
1. Support attention and engagement through use of a) equine movement (i.e., hippotherapy) to facilitate optimal physiological arousal, b) strengths & interests, including preferred equine activities, and c) regulation tools.	1. Support attention and engagement through use of strengths, interests, and regulation tools
2. Provide direct instruction of a self-regulation skill from Zones of Regulation™	2. Provide direct instruction of a self-regulation skill from Zones of Regulation™
3. Offer therapeutic activities with horses to practice the self-regulation skill	3. Offer therapeutic play activities to practice the self-regulation skill
4. Give positive reinforcement for practicing the weekly self-regulation skill (preferred equine activities often the reinforcement)	4. Give positive reinforcement for practicing the weekly self-regulation skill
5. Scaffold skill performance using prompting, fading, shaping, chaining, and feedback	5. Scaffold skill performance using prompting, fading, shaping, chaining, and feedback
6. Create an environment to best support skill performance (horse selection, tack selection, arena set-up)	6. Create an environment to best support individual performance

The same dyads from the 10 weeks of OT-ZOR Clinic were maintained. Dyads attended 10 weekly 60-minute sessions of OT-ZOR Equine. Sessions followed a general structure: greetings, activities with horses, caregiver debrief, goodbyes. The same 10 self-regulation skills from the Zones of Regulation™ curriculum were adapted to be delivered in an equine environment and to fulfill the critical elements in Table 2, which intentionally mirrored all critical elements of OT-ZOR Clinic, but with the addition of purposeful inclusion of horses to augment the intervention (in critical elements #1, #3, #4, and #6).

For example, to work on the first skill of categorizing emotions and alertness states into four zones, the occupational therapists provided the same direct instruction and emotion charades games as previously described for OT-ZOR Clinic, while participants were mounted on a horse (Table 2 elements #2 and #3). Youth then chose how to ride their horse (e.g., walk, trot, side-sitting, etc.) to a barrel with a poster that corresponded with the zone color and taped the emotion onto the poster (element #4- positive reinforcement using preferred activity). Throughout the activity the occupational therapists integrated youths' strengths and interests, including fostering their interest in the horse (element #1), and scaffolded their ability to categorize the emotion into a zone (element #5). Also like OT-ZOR Clinic, joint activities were planned for every session (barring an absence), but the level of engagement between youth varied based on youth's social abilities and social interest.

2.7 Data collection

2.7.1 Aim 1: participant recruitment, attendance, and retention

Table 3 includes benchmarks for each feasibility indicator. We used Excel spreadsheets to monitor recruitment, reasons for ineligibility, attendance, withdrawals, and reasons for withdrawals.

2.7.2 Aim 2: OT-ZOR Equine intervention fidelity, safety & assessment completion

We monitored intervention fidelity using the OT-ZOR Equine fidelity rating form created for this study. The rating form measures the presence and quality of the structural and critical elements of OT-ZOR Equine described above. The first author and a graduate research assistant obtained 97% agreement on use of the OT-ZOR

TABLE 3 Feasibility indicators for intervention implementation and acceptability.

Feasibility Indicator	Feasibility Benchmark	Result
Participant Recruitment	20 participants	20 participants (this paper reports on 14 assigned to OT-ZOR)
Participant Retention	90%	100%
Participant Attendance	90%	95%
Intervention Fidelity	90%	91%
Assessment Completion	90%	93% ABC-C, EDI, SRS-2, WHOQOL- Bref; 50% PEDICAT-ASD
Adverse Events	0 serious adverse events	0 serious adverse events
Caregiver Acceptability	90% satisfied or very satisfied	100% satisfied or very satisfied
Occupational Therapist Acceptability	90% satisfied or very satisfied	100% satisfied or very satisfied

ZOR, Zones of Regulation™; ABC-C, Aberrant Behavior Checklist-Community; EDI, Emotional Dysregulation Inventory; SRS-2, Social Responsiveness Scale, Second Edition; WHOQOL-Bref, World Health Organization Quality of Life Assessment, Brief Version.

Equine fidelity rating form by jointly rating 8 sessions. The first author then rated the fidelity of 26% of OT-ZOR Equine sessions.

We monitored the safety of OT-ZOR Equine using incident report forms completed by occupational therapists that detailed any adverse events that occurred during the intervention.

2.7.3 Aim 3: therapist and caregiver acceptability of OT-ZOR Equine

After OT-ZOR Equine, caregivers completed a satisfaction survey with Likert-scale questions that addressed: perceived benefits of OT-ZOR Equine, the intervention's goodness-of-fit, logistics of attending, and youth's perceived enjoyment/willingness to attend. Open-ended questions asked caregivers about the best and worst aspects of OT-ZOR Equine, and suggestions for improvement.

Both occupational therapists completed an online satisfaction survey after delivering two 10-week sessions of OT-ZOR Equine. Likert-scale and open-ended questions focused on overall satisfaction, perceived appropriateness of OT-ZOR Equine, logistical feasibility, intent to continue use, and suggestions for improvement.

Both occupational therapists also participated in a focus group online through Microsoft Teams after two 10-week sessions of OT-ZOR Equine. The first author led the focus group using a semi-structured guide that included open-ended questions about overall satisfaction, perceived appropriateness of OT-ZOR Equine, logistical feasibility, intent to continue use, and suggestions for improvement.

2.7.4 Aim 4: preliminary participant outcomes

Caregivers completed outcomes measures online three times: Time 1 pretest, Time 2 after OT-ZOR Clinic, and Time 3 after OT-ZOR Equine. All caregiver-completed outcome assessments were completed on a secure web-based platform called REDCap, with the exception of one assessment that had to be completed on Pearson's secure online Q-Global platform (the Pediatric Evaluation of Disability Inventory Computer Adaptive Test).

2.7.4.1 Aberrant Behavior Checklist, Community (ABC-C)

Caregivers completed the irritability and hyperactivity scales of the ABC-C (37), a measure of the presence and severity of problem behaviors. In the absence of targeted interventions, test-retest reliability of caregiver-ratings on the ABC-C is stable, ranging from r=0.80 to r=0.95. This measure, frequently used in clinical trials in ASD research (38), has concurrent validity with other measures of behavior (37).

2.7.4.2 Emotional Dysregulation Inventory (EDI)

The EDI (39) is a 30-item assessment that quantifies emotional dysregulation in autistic youth. The EDI, which was developed with methods from item response theory, results in a total score for emotional reactivity ("intense, rapidly escalating, sustained, and poorly regulated negative emotional reactions" p. 928) and dysphoria ("characterized by anhedonia, sadness, and nervousness" p. 928). It has concurrent validity with other behavioral measures of emotional dysregulation, anxiety, depression, irritability, hyperactivity, and aggression; has good test-retest reliability in the absence of interventions (emotional reactivity mean difference = 0.05; dysphoria mean difference = 0.02); and is sensitive to changes in emotional dysregulation following intervention (emotional reactivity mean difference = 1.21; dysphoria = 0.70).

2.7.4.3 Social Responsiveness Scale, Second Edition (SRS-2)

The SRS-2 (40) is a 65-item questionnaire that measures autism-specific social functioning in five subscales: social awareness, social cognition, social motivation, social communication, and restricted interests and repetitive behaviors. The SRS-2 has evidence of internal consistency, Cronbach's α=0.95 for clinical samples, test-retest reliability ranging between r=0.88 and r=0.95, and concurrent validity with other social behavior measures (41).

2.7.4.4 World Health Organization Quality of Life- BREF (WHOQOL-BREF)

The WHOQOL-BREF (42) is a 26-item measure of caregiver quality-of-life across four domains: physical health, psychological, social relationships, and environment. This measure has established discriminant and content validity, good test-retest reliability (Cronbach's α=0.66 – 0.84), and has been validated in parents of autistic youth (43).

2.7.4.5 Pediatric Evaluation of Disability Inventory Computer Adaptive Test for Autism Spectrum Disorder (PEDICAT-ASD)

The PEDICAT-ASD (44) is a caregiver-report measure of child performance and participation in 4 functional areas: mobility, social/cognitive, daily activities, and responsibility. This version of the PEDICAT was modified specifically for autistic youth, with excellent test-retest reliability in the absence of intervention (ICC ≥0.86) and concurrent validity with other measures of adaptive behavior.

2.7.4.6 Goal Attainment Scaling (GAS)

Goal attainment scaling is a standardized method for measuring progress on individual, functional goals and is regarded as a useful outcome measure of individual progress in intervention studies for ASD (45). The first author trained occupational therapists in implementation of GAS according to procedures described by McDougall and King (46). Occupational therapists collaboratively determined goal areas with parents and participants via a standardized semi-structured interview, in line with current GAS recommendations (45, 47). Guided by this semi-structured interview, self-regulation goals pertained to 1) identifying emotions, 2) identifying self-regulation tools/strategies, and 3) using self-regulation tools/strategies. Occupational therapists used a template to ensure that goals were systematically scaled across participants. Per this method, occupational therapists scaled goals onto a 5-point scale, where -2 indicated the level of performance at the time of evaluation, -1 indicated less-than-expected level of performance after the intervention, 0 indicated the expected level of performance after the intervention (the "goal level"), +1 indicated more-than-expected performance after the intervention, and +2 indicated much-more-than-expected performance after the intervention. The first author verified that all defined goals both addressed self-regulation skills and met the criteria outlined in McDougall and King's (46) GAS checklist.

Following each ten-week session of OT-ZOR Clinic or OT-ZOR Equine, an occupational therapist blinded to the treatment conditions of each participant conducted a semi-structured interview with each participant's caregiver in order to rate the youth's goal attainment on their individual goals. Parents remained blinded to the numerical values of each rating, as well as to the specific behavioral benchmarks in the GAS scales. As participant behavior tends to improve in the context of therapy, we chose to depend upon caregiver-report of participants' performance to ensure GAS ratings were representative of participant behavior in home and community contexts. In order to establish interrater reliability, AH listened to a random 69% of recorded caregiver interviews and rated the child's goal attainment.

2.8 Data analysis

We used Microsoft Excel to calculate descriptive statistics of quantitative feasibility and acceptability data. Focus group data was transcribed verbatim using Microsoft Word and uploaded into NVivo Qualitative Software. Open-ended survey responses were also uploaded into NVivo. AH conducted a directed content analyses (48) of qualitative data using Nvivo Qualitative software. Content analyses began with pre-determined parent codes derived from indicators of acceptability (49). AH then inductively generated child codes within each parent code, and new parent codes as needed. Next, she created narrative summaries of the data, informed by peer-review from the first author.

To assess preliminary participant outcomes, we conducted a repeated measures ANOVA using a linear mixed effects model with unstructured covariance to compare outcomes at three time-points: Time 1 pretest, Time 2 after OT-ZOR Clinic, and Time 3 after OT-ZOR Equine. For the analysis, we included participants with outcome data at 2 or more timepoints: Time 1 & 2 (n=1) and Time 1, 2, and 3 (n=13). No adjustment for type I errors for multiple comparisons or multiple outcomes were applied for this exploratory feasibility study. P-value < 0.05 was deemed statistically significant. All p-values are reported.

3 Results

Figure 2 is a modified CONSORT diagram that illustrates participant progression through the study. Table 4 presents demographic and clinical characteristics of participants who completed OT-ZOR Clinic and OT-ZOR Equine, and their caregivers. Table 3 presents results of each feasibility indicator, as next described.

3.1 Aim 1: participant recruitment, attendance, and retention

Twenty-six participants were assessed for eligibility, six were excluded because they did not meet the ABC-C irritability inclusion criteria (n=4) or they chose not to participate (n=2). Ten participants were enrolled into the first cohort within three months of recruitment, and an additional ten were enrolled in the second cohort within an additional four months. Recruitment ended after 20 participants enrolled in the study. Fourteen of 20 participants met inclusion criteria for OT-ZOR Equine (Table 1) and are therefore included in the results of this paper. No participants discontinued the OT-ZOR Equine intervention, resulting in 100% retention. In line with exclusion criteria three (Table 1), we monitored participant therapy changes throughout the study period; no youth started new therapies during the study period. Youth attended 95% of OT-ZOR Equine sessions; seven participants missed one session each.

3.2 Aim 2: OT-ZOR Equine intervention fidelity, safety, and assessment completion

On average, both occupational therapists attained 91% fidelity to the OT-ZOR Equine intervention; fidelity scores ranged from 72% to 100%.

TABLE 4 Participant and caregiver characteristics.

Participant Characteristic	Mean ± SD or Count N=14
Age	8.8 ± 2.6
ABAS-3 General Adaptive Composite	74.5 ± 11.88
SCQ Total	20.0 ± 4.3
Total Irritability Score	24.3 ± 7.8
Sex (M/F)	6/8
Race	
Black or African American	1
White	10
Multiracial	3
Ethnicity (Hispanic or Latino)	0
Household Income	
≤ $50,000	6
$51,000 - $100,000	4
>100,000	4
Caregiver Age	35.7 ± 4.8
Caregiver Sex (M/F)	1/13
Caregiver Race	
White	13
American Indian/Alaskan Native	1
Caregiver Ethnicity (Hispanic or Latino)	0

ABAS-3, Adaptive Behavior Assessment System, Third Edition; SCQ, Social Communication Questionnaire.

No serious adverse events occurred during OT-ZOR Equine. One non-serious adverse event occurred; a horse briefly nipped a participant on the arm, causing mild bruising. No follow-up medical care was required, and no other safety events were reported throughout the OT-ZOR Equine intervention.

Thirteen caregivers completed five out of six outcome assessments after OT-ZOR Equine; one caregiver was lost to follow-up as she no longer lived in the same household as her child at the post-test assessment. However, only seven caregivers completed the PEDICAT-ASD outcome measure, likely because it had to be completed on a different online platform (Pearson's Q-Global) than the rest of the outcome battery.

3.3 Aim 3: OT-ZOR Equine acceptability

3.3.1 Caregiver acceptability survey

One hundred percent of caregivers who completed the acceptability survey (n=13) agreed or strongly agreed they were overall satisfied with the OT-ZOR Equine intervention. Caregivers were most satisfied with the goals the intervention addressed, the rapport their child built with the occupational therapist, and reported they would recommend the OT-ZOR Equine intervention to another caregiver with an autistic child (100% agreed or strongly agreed). Ninety-two percent of caregivers agreed or strongly agreed that OT-ZOR Equine was a good fit for their child, and that their child enjoyed it. Eighty-five percent of caregivers believed OT-ZOR Equine was beneficial for their child, and that their child was agreeable to attend. However, only 62% of caregivers agreed or strongly agreed that OT-ZOR Equine was logistically feasible to attend (time of day, driving distance, etc.).

In the open-ended responses, caregivers expressed overall satisfaction with the OT-ZOR Equine intervention, particularly that their children not only *"loved"* their experiences in OT-ZOR Equine, but also demonstrated observable improvements following the intervention. Caregivers expressed satisfaction with their children's "*opportunity to work with horses*" throughout the OT-ZOR intervention, one caregiver stating, *"We found out he absolutely loves horses and the riding had such a calming effect on him."* Caregivers were complimentary of the high-quality, trusting therapist-client relationships their children formed with the occupational therapists, as well as of the "*new skills*" that their children learned via OT-ZOR Equine. There were few negative comments regarding the intervention, with a few critiques concerning the long commute to the facility on the outskirts of town and that OT-ZOR Equine sessions were often scheduled during school hours (due to the facility's 8am-5pm schedule). Overall, parents had few suggestions to improve the OT-ZOR Equine intervention, with some parents noting that they would like the option for more after-school scheduling availability as well as a greater frequency of sessions throughout the study.

3.3.2 Occupational therapist acceptability survey

Both occupational therapists agreed or strongly agreed that they were satisfied with the OT-ZOR Equine intervention, particularly that it was appropriate for autistic youth and logistically feasible to implement. They both agreed or strongly agreed that they would continue to implement the OT-ZOR Equine intervention after the study concluded, and that they would recommend OT-ZOR Equine to other occupational therapists.

In response to open-ended survey questions, occupational therapists regarded the structure of the intervention and the presence of the horses as the salient positive aspects of OT-ZOR Equine intervention, stating, *"participants seemed responsive and motivated using equines,"* and, *"The equines allowed for pressure to be taken off the youth and anxiety decreased when practicing [self-regulation skills]"* When asked about the worst part of OT-ZOR Equine, occupational therapists referenced the time commitment required to complete the documentation forms.

3.3.3 Occupational therapist focus group

Overall, occupational therapists were satisfied with their experiences taking part in this study and noted particular satisfaction with the content of the OT-ZOR Equine evaluation and intervention, the goal attainment scaling process, and the OT-ZOR Equine manual. Therapists expressed intent to incorporate several components of this study's evaluation process into their

clinical practice, including goal attainment scaling and use of the occupational profile. Therapists suggested that teenage participants may benefit from more detailed descriptions about OT-ZOR Equine prior to the start of their participation: "*That would have been helpful, so that he knew what we were going to talk about.*" Occupational therapists considered OT-ZOR Equine to be occupation-based, and appropriate for occupational therapists to deliver to autistic youth in an equine environment. They noted that multiple participants were motivated by unmounted equine activities, such as groundwork, and suggested the addition of unmounted activities in future studies, even if that addition would slightly decrease mounted time. As well, while occupational therapists generally reacted positively to the Zones of Regulation™ curriculum, they felt that increased training time on the program prior to implementation, and a more structured implementation scheme—such as introducing one Zones of Regulation™ *tool* to participants at the start of each intervention session—would both help the therapists better understand the program and expose youth participants to the curriculum's tools more naturally.

3.4 Aim 4: OT-ZOR Equine preliminary participant outcomes

Table 5 presents preliminary participant outcomes.

3.4.1 OT-ZOR clinic fidelity & attendance

While Peters et al. (28) provides a full report on the feasibility of OT-ZOR Clinic, to provide context for the analyses of preliminary participant outcomes below, in this paper we report attendance and fidelity. Participants attended 94% of OT-ZOR Clinic sessions, with eight participants missing one session each. Providers achieved 97% fidelity to the OT-ZOR Clinic intervention.

3.4.2 Self-regulation

Figure 3 illustrates participant outcomes on indicators of self-regulation as measured by the ABC-C and EDI. There were statistically significant differences between measurement timepoints in irritability, hyperactivity, emotional reactivity, and dysphoria (Table 5). Mixed model analyses revealed that each of

TABLE 5 Participant outcomes.

Outcome	*F*	Comparison	Difference	DF	*t*	*p*
ABC-C Irritability	**8.74****	**(1. Baseline) - (2. Clinic)**	**5.6**	**13**	**2.79**	**0.015***
		(1. Baseline) - (3. Equine)	**6.9**	**13**	**4.16**	**0.001****
		(2. Clinic) - (3. Equine)	1.3	13	0.96	0.356
ABC-C Hyperactivity	**7.57****	**(1. Baseline) - (2. Clinic)**	**5.8**	**13**	**2.80**	**0.015***
		(1. Baseline) - (3. Equine)	**7.1**	**13**	**3.89**	**0.002****
		(2. Clinic) - (3. Equine)	1.3	13	0.94	0.365
EDI Emotional Reactivity	**7.74****	**(1. Baseline) - (2. Clinic)**	**4.4**	**13**	**2.61**	**0.021***
		(1. Baseline) - (3. Equine)	**5.1**	**13**	**3.85**	**0.002****
		(2. Clinic) - (3. Equine)	0.7	13	0.44	0.664
EDI Dysphoria	**6.78***	**(1. Baseline) - (2. Clinic)**	**3.8**	**13**	**2.80**	**0.015***
		(1. Baseline) - (3. Equine)	**5.1**	**13**	**3.61**	**0.003****
		(2. Clinic) - (3. Equine)	1.3	13	1.08	0.301
SRS-2 Social Awareness	0.71	(1. Baseline) - (2. Clinic)	-1.7	13	-0.81	0.431
		(1. Baseline) - (3. Equine)	0.7	13	0.39	0.699
		(2. Clinic) - (3. Equine)	2.4	13	1.19	0.256
SRS-2 Social Cognition	**4.52***	(1. Baseline) - (2. Clinic)	1.6	13	0.54	0.596
		(1. Baseline) - (3. Equine)	**4.0**	**13**	**2.24**	**0.043***
		(2. Clinic) - (3. Equine)	2.4	13	1.32	0.209
SRS-2 Social Communication	**9.90****	(1. Baseline) - (2. Clinic)	-1.1	13	-0.62	0.547
		(1. Baseline) - (3. Equine)	**4.0**	**13**	**2.21**	**0.045***
		(2. Clinic) - (3. Equine)	**5.1**	**13**	**4.42**	**<.001****

(Continued)

TABLE 5 Continued

Outcome	*F*	Comparison	Difference	DF	*t*	*p*
SRS-2 Social Motivation	1.25	(1. Baseline) - (2. Clinic)	3.2	13	1.53	0.149
		(1. Baseline) - (3. Equine)	1.2	13	0.54	0.601
		(2. Clinic) - (3. Equine)	-2.0	13	-0.97	0.350
SRS-2 RRB	2.00	(1. Baseline) - (2. Clinic)	1.6	13	0.83	0.423
		(1. Baseline) - (3. Equine)	4.4	13	1.93	0.075
		(2. Clinic) - (3. Equine)	2.8	13	1.50	0.158
SRS-2 Total	**5.40***	(1. Baseline) - (2. Clinic)	0.4	13	0.21	0.833
		(1. Baseline) - (3. Equine)	**3.8**	**13**	**2.20**	**0.046***
		(2. Clinic) - (3. Equine)	**3.4**	**13**	**2.72**	**0.017***
WHOQOL-BREF Physical Health	**4.05***	(1. Baseline) - (2. Clinic)	0.0	13	0.00	1.000
		(1. Baseline) - (3. Equine)	**-1.2**	**13**	**-2.35**	**0.035***
		(2. Clinic) - (3. Equine)	**-1.2**	**13**	**-2.49**	**0.027***
WHOQOL- BREF Psychological	2.10	(1. Baseline) - (2. Clinic)	-0.7	13	-1.73	0.106
		(1. Baseline) - (3. Equine)	-0.6	13	-0.85	0.409
		(2. Clinic) - (3. Equine)	0.2	13	0.42	0.681
WHOQOL-BREF Social Relationships	1.9	(1. Baseline) - (2. Clinic)	-1.5	13	-1.93	0.075
		(1. Baseline) - (3. Equine)	-1.1	13	-1.27	0.228
		(2. Clinic) - (3. Equine)	0.4	13	0.53	0.602
WHOQOL-BREF Environment	0.35	(1. Baseline) - (2. Clinic)	-0.4	13	-0.69	0.500
		(1. Baseline) - (3. Equine)	-0.4	13	-0.67	0.512
		(2. Clinic) - (3. Equine)	0.1	13	0.12	0.907

ABC-C, Aberrant Behavior Checklist-Community; EDI, Emotional Dysregulation Inventory; SRS-2, Social Responsiveness Scale, Second Edition; WHOQOL-Bref, World Health Organization Quality of Life Assessment, Brief Version; Clinic, Occupational Therapy using Zones of Regulation™ Concepts in a Clinic; Equine, Occupational Therapy using Zones of Regulation™ Concepts in an Equine Environment.
Bold indicates $p<0.05$.
* indicates $p<0.05$; ** indicates $p<0.01$.

these indicators of self-regulation were significantly improved after OT-ZOR Clinic (Time 2) and OT-ZOR Equine (Time 3) in comparison to baseline (Time 1). There were no significant differences in any of these self-regulation indicators when comparing post-OT-ZOR Clinic (Time 2) and post-OT-ZOR Equine (Time 3). Overall then, participants demonstrated the greatest improvements in self-regulation after OT-ZOR Clinic, and these improvements maintained but plateaued after OT-ZOR Equine. It is worth noting, after 10 weeks of OT-ZOR Clinic several participants had dropped below the inclusion criteria of ABC-C irritability scores >10, therefore, the plateau in improvement in self-regulation indicators after OT-ZOR Equine could represent a floor effect.

3.4.3 Social functioning

Figure 4 illustrates participant outcomes on indicators of social functioning, as measured by the SRS-2. There were significant differences between measurement timepoints in total social functioning, social communication, and social cognition (Table 5). Mixed model analyses revealed that total social functioning and social communication were significantly improved after OT-ZOR Equine (Time 3) in comparison to baseline and post-OT-ZOR Clinic (Times 1&2). Furthermore, social cognition was significantly improved after OT-ZOR Equine (Time 3) in comparison to baseline (Time 1). There were no significant differences in any of these indicators of social functioning after OT-ZOR Clinic (Time 2) compared to baseline (Time 1). Overall then, participants did not demonstrate significant improvements in social functioning after OT-ZOR Clinic, but then demonstrated significant improvements particularly in social communication and social cognition after OT-ZOR Equine.

3.4.4 Caregiver quality of life

There were significant differences between measurement timepoints in the physical health domain of caregiver quality of life of the WHOQOL-Brief (Table 5). Mixed model analyses revealed caregivers' physical health was greater after OT-ZOR Equine (Time 3) in comparison to baseline or post-OT-ZOR

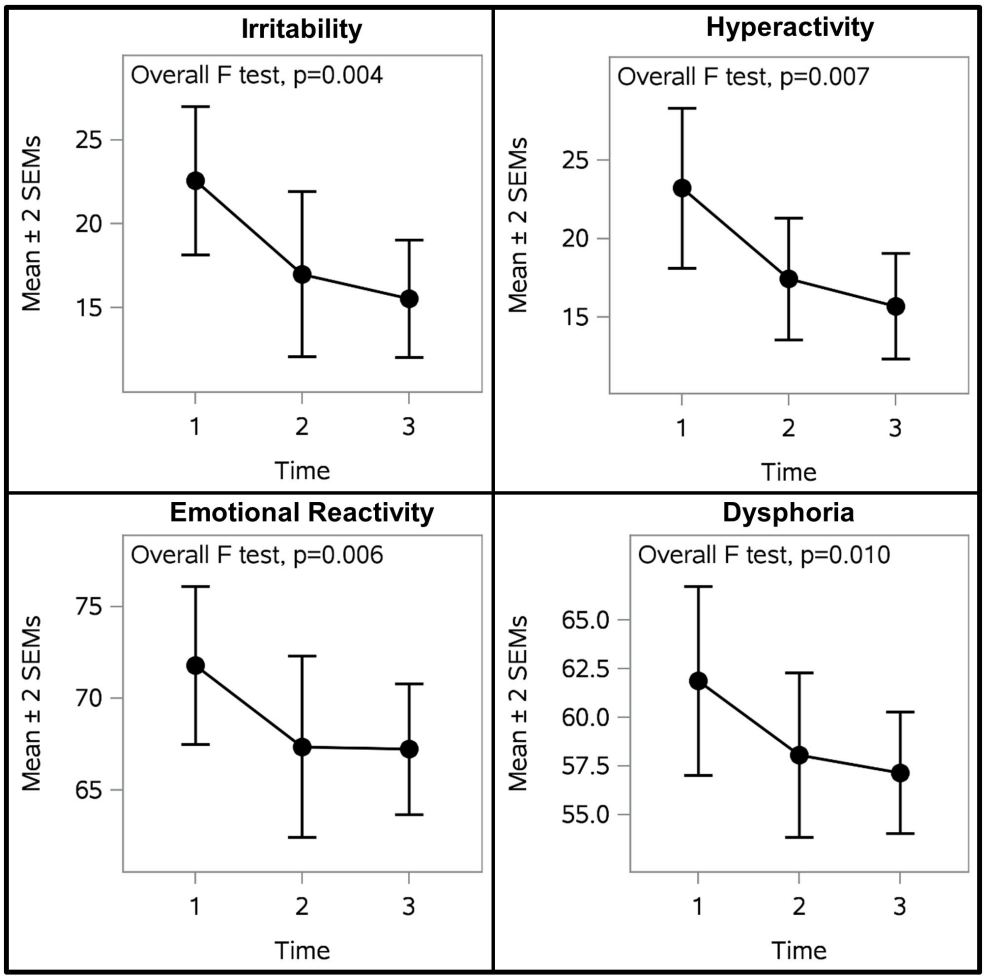

FIGURE 3
Participant Self-regulation Outcomes. Participants demonstrated significnatly improved self-regulation across all four self-regulation indicators. The largest improvements occurred after OT-ZOR Clinic (Time 2). Improvements were maintained but plateaued after OT-ZOR Equine (Time 3). Time 1=Baseline; Time 2= After OT-ZOR Clinic; Time 3=After OT-ZOR Equine.

Clinic (Times 1 & 2). There were no significant differences in caregivers' physical health after OT-ZOR Clinic (Time 2) in comparison to baseline (Time 1). Overall, caregivers' quality of life did not change after OT-ZOR Clinic, but was significantly improved in the domain of physical health after their child participated in the OT-ZOR Equine intervention.

3.4.5 Goal attainment

Table 6 provides example participant goals. Figure 5 illustrates participant progress on individual self-regulation goals after OT-ZOR Clinic and OT-ZOR Equine. We attained 94% interrater reliability on goal ratings. Seventy-nine percent of participants met or exceeded their individual occupational performance goal related to self-regulation after participation in OT-ZOR Clinic, as indicated by a post-test GAS score of 0, + 1, or +2. Sixty-one percent of participants met or exceeded their primary individual occupational performance goal related to self-regulation after participation in OT-ZOR Equine, as indicated by a post-test GAS score of 0, + 1, or +2.

4 Discussion

This paper aimed to evaluate the feasibility of an updated intervention protocol, OT-ZOR Equine, specifically evaluating: 1) participant recruitment, retention, and attendance, 2) intervention fidelity, safety, and caregiver assessment completion, 3) acceptability of the OT-ZOR Equine intervention to providing occupational therapists and caregivers of autistic youth, and 4) preliminary participant outcomes after the OT-ZOR Equine intervention.

We found the intervention and study protocol largely feasible to implement, as demonstrated by exceeding feasibility benchmarks in recruitment, retention, attendance, fidelity, and safety. We successfully recruited 20 participants within a reasonable timeframe, notably recruiting more female than male participants. Historically females are underrepresented in autism research (50–52), our success in recruiting female participants may be attributed to the inclusion of horses in our recruitment materials, as autistic girls identify animals as a special interest more often than autistic boys (53, 54). However, the sample of participants in the current

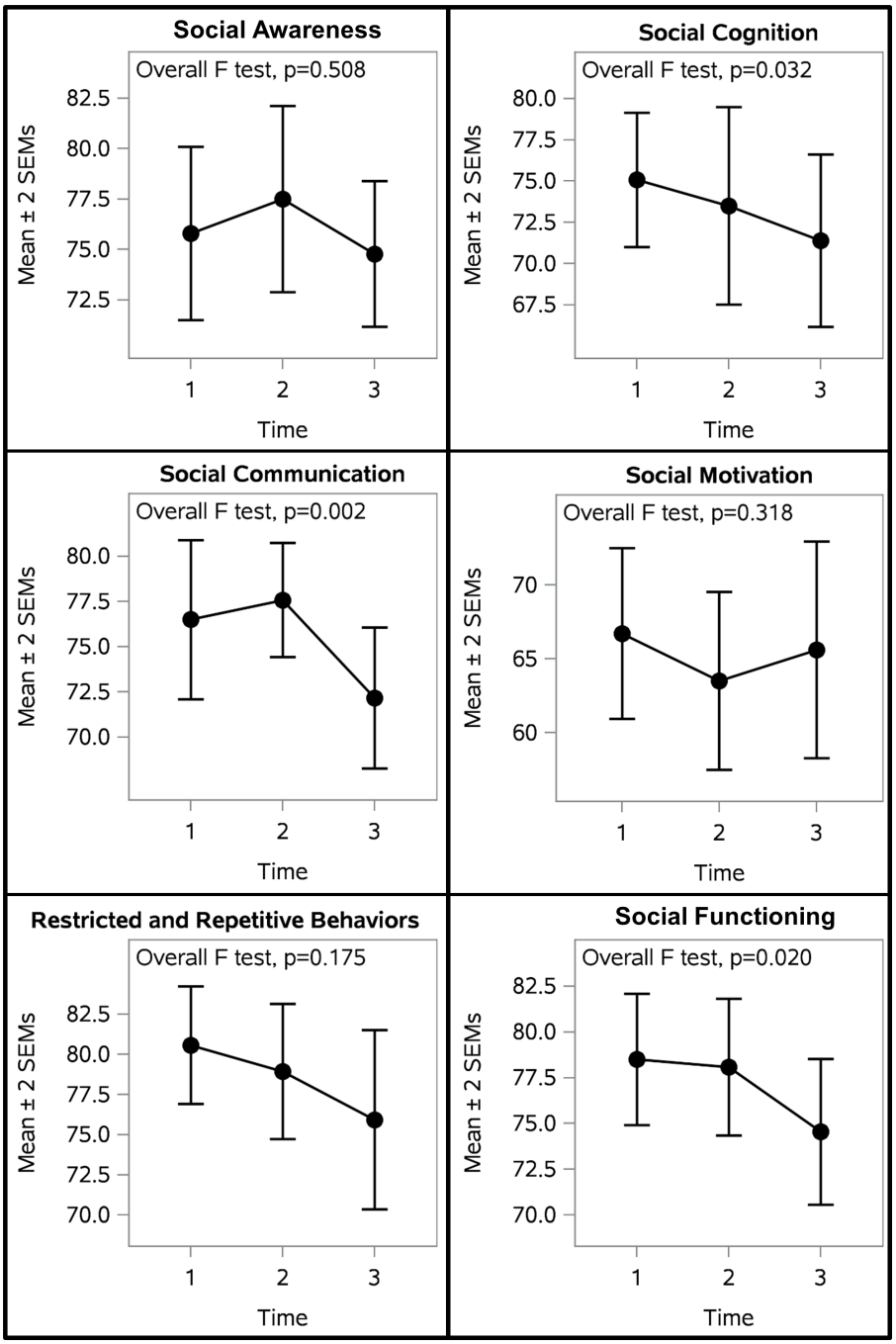

FIGURE 4
Participant Social Outcomes. Participants demonstrated significantly improved social cognition, social communication, and total social functioning. There were no significant differences after OT-ZOR Clinic (Time 2), but significant improvements after OT-ZOR Equine (Time 3). Time 1=Baseline; Time 2= After OT-ZOR Clinic; Time 3=After OT-ZOR Equine.

study was not racially or ethnically diverse; recruitment efforts in future studies should partner with local communities to intentionally recruit a more diverse sample.

Assessing intervention acceptability is a critical research task in designing and evaluating interventions (29, 55), as an intervention's acceptability to both the recipient and the healthcare provider may affect its implementation, participant adherence, and overall effectiveness (56). Caregivers generally found the OT-ZOR Equine intervention acceptable, as evidenced by 100% satisfaction rates, 100% retention in the study, and high attendance. This mirrors the high acceptability ratings of caregivers of youth who participated in the OT^{ee} HORSPLAY intervention (27), suggesting the modifications to the OT-ZOR Equine intervention protocol to increase standardization did not decrease caregiver acceptance. Following advice from caregiver's suggested improvements, future studies can offer more after-school times and offer OT-ZOR Equine at facilities closer to suburbs/cities (as opposed to the more rural location in the current study). Furthermore, the caregiver outcome

TABLE 6 Example self-regulation goals.

Self-regulation Area	Example Goal
Understanding Emotions	Jaime names a complex emotion in himself when becoming dysregulated (e.g., disappointed, overwhelmed) with 2 verbal cues in 80% of opportunities.
Identifying self-regulation tools	Emma names a self-regulation tool that can help her calm down when provided with a verbal or visual prompt by her parent.
Using self-regulation tools	Micah uses a self-regulation tool while in the "yellow zone" (starting to become upset) 70% of the time with 3 verbal or visual cues from mom.

battery was largely feasible, apart from one assessment that had to be completed on a different online platform (PEDICAT-ASD). Future OT-ZOR Equine research should use an outcome measure of adaptive behavior that can be completed on the same platform as all other outcome measures, and could recruit teachers to report on participants' behavior at school, to assess if potential improvements in social functioning and self-regulation have an impact on youths' daily lives.

Similarly, occupational therapists found the OT-ZOR Equine intervention acceptable, and they were able to implement it safely and with high fidelity to the intervention protocol. This also mirrors the high therapist acceptance of the OT^{ee} HORSPLAY intervention (27), and indicates that the modifications to the OT-ZOR Equine protocol successfully increased standardization without losing the client-centered individualization that is essential to occupational therapy practice (57).

Preliminary participant outcomes suggest that self-regulation indicators improved after OT-ZOR Clinic and plateaued after OT-ZOR Equine, but we do not know if participants would have demonstrated the same improvements had they participated in OT-ZOR Equine first. Preliminary participant outcomes also suggest that OT-ZOR Equine may offer additive benefits in social functioning, particularly social communication, compared to OT-ZOR Clinic. These findings are consistent with social communication improvements seen after several different equine-assisted services for autistic youth (58).

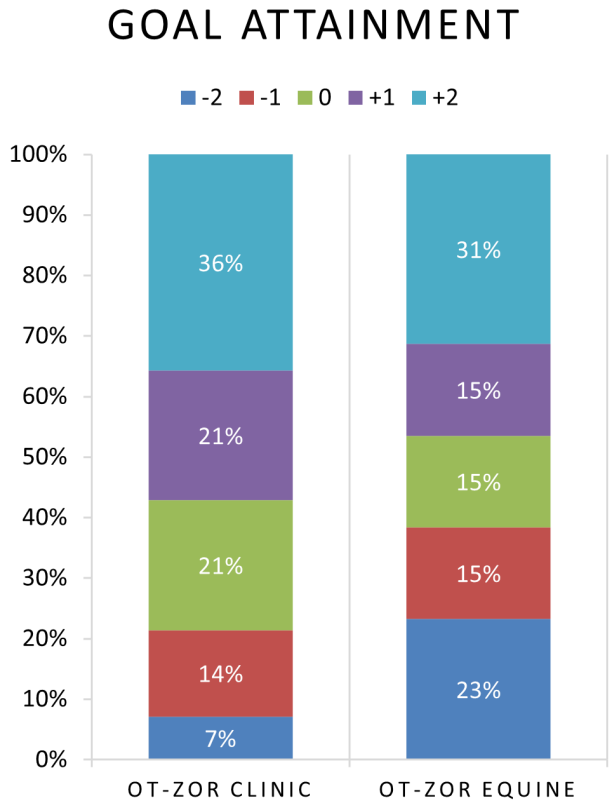

FIGURE 5
Distribution of goal attainment ratings after OT-ZOR Clinic and OT-ZOR Equine. OT-ZOR Clinic=Occupational Therapy using Zones of Regulation™ Concepts in a Clinic; OT-ZOR Equine=Occupational Therapy using Zones of Regulation™ Concepts in an Equine Environment. -2=level of performance at the time of evaluation; -1=less-than-expected level of performance after the intervention; 0=expected level of performance after the intervention; +1=more-than-expected performance after the intervention; +2=much-more-than-expected performance after the intervention.

4.1 Limitations

This study occurred in 2021 as the US was emerging from the COVID-19 pandemic, so school re-openings, masking, and a variety of other historical factors likely affected the outcomes. The study is also limited by a small, non-diverse sample and reliance on parent-report outcome measures, which could be biased by caregivers' investment in the therapy process. Finally, most caregivers enrolled in the study were youths' mothers; therefore, this study does not represent fathers' views on the acceptability or preliminary outcomes of the intervention, which may differ from mothers' perspectives.

The current study was designed to assess *feasibility* of OT-ZOR Equine, and we are limited in our ability to draw efficacy conclusions due to possible order effects, attention effects, or the effect of the time of year on outcomes. Since all participants received OT-ZOR Clinic first, followed by OT-ZOR Equine, we are unable to draw efficacy conclusions about OT-ZOR Equine alone. Historical effects are also of particular concern, given data collection occurred in 2021 as the US was emerging from the COVID-19 pandemic. For instance, significant improvements in caregiver physical quality of life may have been impacted by the receding COVID-19 pandemic (e.g., questions such as "how satisfied are you with your capacity for work?" may have been impacted by easing social distancing and remote-work requirements). Further, school re-openings with masking requirements may have affected the lack of improvement in participants' social motivation. Notwithstanding, these promising preliminary participant outcomes suggest the need for a larger randomized controlled trial that randomly assigns participants to receive either OT-ZOR Equine or OT-ZOR Clinic to assess the additive benefit of integrating horses into occupational therapy on self-regulation and social outcomes in autistic youth. In future efficacy studies researchers should recruit a larger diverse sample, randomly assign participants to conditions, and include physiological indicators of self-regulation in the outcome battery.

4.2 Conclusion

OT-ZOR Equine is feasible to implement, acceptable to recipients' caregivers and providing occupational therapists, and may offer additive improvements in social functioning compared to occupational therapy without horses. This study provides a strong foundation for a future randomized controlled trial to assess the efficacy of integrating horses into occupational therapy to improve self-regulation and social outcomes in autistic youth.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Colorado State University IRB #2. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

BP: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. RG: Supervision, Writing – review & editing. AS: Supervision, Writing – review & editing. ZP: Formal analysis, Writing – review & editing. TM: Project administration, Writing – review & editing. AH: Formal analysis, Writing – original draft. SH: Funding acquisition, Methodology, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was funded by the Colorado State University Human-animal Interaction Pilot Grant, administered through the Human-animal Bond in Colorado. The study was also supported by NIH/NCATS Colorado CTSA Grant Number UL1 TR002535. Its contents are the authors' sole responsibility and do not necessarily represent official NIH views.

Acknowledgments

We are grateful to the youth and their families for their participation in this study. We would also like to thank Liz Ampe, Beth Liesenfeld, Erin Kelly, and Rebecca Reinhardt for their help conducting the study. Finally, we are grateful to the wonderful staff and volunteers at Hearts & Horses, Inc. and Temple Grandin Equine Center who made this study possible.

Conflict of interest

Author TM was employed by Hearts & Horses, Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Clinical Trial
PUBLISHED 15 October 2024
DOI 10.3389/fpsyt.2024.1432679

OPEN ACCESS

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RECEIVED 14 May 2024
ACCEPTED 16 September 2024
PUBLISHED 15 October 2024

CITATION
Schmid P, Nauss C, Jauch-Ederer C, Prinz P, Tschöke S and Uhlmann C (2024) Can sheep help to improve positive emotions, mindfulness, and self-efficacy expectancy? A pilot study of animal-assisted intervention as an enhanced CBT-based therapy for substance use disorders.
Front. Psychiatry 15:1432679.
doi: 10.3389/fpsyt.2024.1432679

Can sheep help to improve positive emotions, mindfulness, and self-efficacy expectancy? A pilot study of animal-assisted intervention as an enhanced CBT-based therapy for substance use disorders

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Introduction: Substance use disorders (SUDs) are common, and there is evidence of clinically significant benefit of cognitive behavioral therapy (CBT). The efficacy of CBT in SUDs has been confirmed, although relapse rates of 40%–60% have been reported. An enhancement of CBT-based therapy through an animal-assisted intervention (AAI) with sheep to normalize the occurrence of negative emotions and improve positive emotions as well as mindfulness and self-efficacy expectancy was investigated.

Methods: A single-session AAI with sheep in a group setting was investigated against treatment as usual over time. N = 36 psychiatric inpatients with SUDs were examined by questionnaires before and 1 week after the intervention and additionally immediately after the intervention.

Results: Positive emotions improved significantly in the AAI group 1 week after the intervention with a medium effect size, but not in the control group. Similarly, mindfulness and self-efficacy expectancy improved over time in the AAI group. When exploratory results were evaluated immediately after the intervention while still on the farm, the effects in favor of AAI were even larger.

Conclusions: AAI can thus be considered effective in improving positive emotions, mindfulness, and self-efficacy expectancy. The impressive effect sizes immediately after the intervention encourage us to consider what can be done to maintain these even greater effect sizes over time.

Clinical Trial Registration: https://drks.de/search/de/trial/DRKS00027539, identifier DRKS 00027539.

KEYWORDS

animal-assisted intervention, sheep, psychiatric, inpatient, addiction, emotion, substance use disorder

Introduction

Substance use disorders (SUDs) have a high prevalence worldwide (1). Men are 1.5 to 2.3 times more likely to be affected than women (2). Biological (genetics and developmental stages of the brain) and social (adverse childhood experiences, high stress levels, easy access to drugs, and low social support) factors are recognized as contributing to vulnerability or resilience against the development of SUDs. With regard to the treatment of SUDs, there is evidence of clinically significant benefit of behavioral therapies (1). Cognitive behavioral therapy (CBT) is based on the assumption that behaviors, including substance use, are learned. Through reinforcement processes, the neurobiologically determined rewarding properties of substances (mediated in particular by dopamine) are associated with previously unconditioned stimuli so that a consumption behavior arises and is later maintained (for a detailed overview, see 1). CBT aims to interrupt these learned associations to reduce the likelihood of substance use, manage its consequences, and intervene quickly in the event of relapse (1, 3, 4). This may be achieved by promoting awareness of behavioral patterns and providing the patient with a set of coping skills to functionally regulate negative, as well as positive emotions (1, 3). Self-efficacy, defined as confidence in one's ability to resolve situations by applying one's skills (5), increases the likelihood of applying acquired skills and thus also reduces the likelihood of substance use. The efficacy of CBT in SUDs has been confirmed (6), although relapse rates of 40%–60% have been reported (7). Some shortcomings of CBT in SUDs are described. First, CBT focuses heavily on avoidance goals (e.g., risk situations) rather than developing approach-based goals with patients (8). Second, CBT usually works on affect regulation with the goal of cessation of negative emotional states instead of normalizing the occurrence of negative emotions (8) and fostering positive emotions. These may be the key issues for therapeutic success, as SUDs are associated with high levels of negative emotionality and dysfunction in emotion regulation (9), possibly due to traumatic experiences prior to SUDs. For this reason, a non-judgmental mindful perception and acceptance of negative emotions and at the same time an activation of positive emotions is needed to improve treatment of SUD. This could be achieved with an approach based on mindfulness. Mindfulness is defined as an intentional, conscious focus on the immediate, present perception (not on the past or future), which is non-judgmental with regard to thoughts and feelings and is characterized by openness and curiosity (10, 11). In particular, the ability to adopt a non-judgmental and non-reactive attitude toward experiences proved to be a decisive factor for a positive correlation between mindfulness and functional emotion regulation (12). Also, increasing self-efficacy expectations is an important factor in SUD treatment (13). The processes described above could be achieved, for example, through animal-assisted interventions (AAIs) (14). AAI includes interventions that involve animals to positively impact human health and wellbeing (15). AAIs comprise both animal-assisted therapy (AAT) and animal-assisted activity (AAA) (16). AAAs are defined as informal human–animal interactions and interventions conducted by human–animal teams that are goal oriented for motivational, educational, and recreational purposes. AATs, in contrast, are also goal oriented but comprise structured and individualized therapeutic interventions. They are often delivered or directed by licensed healthcare professionals as part of a treatment process (16).

Several reviews on the efficacy of AAI are already available (17–21). They report improvements in positive emotions, social behavior, and level of functioning, while agitated behavior, negative emotions such as anxiety, or clinical symptoms such as depression can be reduced (17, 19, 20). In contrast, reviews criticize both the heterogeneity of the included studies and methodological shortcomings, such as small samples, lack of randomized controlled trials (RCTs), lack of standardization or manualization of interventions, and use of non-specific outcome measures (17, 18, 20). Thus, although there is currently a consensus on the efficacy of AAIs in healthcare, it is not possible to speak of existing evidence (22), and also specific and non-specific factors of AAI have not yet been identified (23).

Therefore, regardless of the reviews, it is worth taking a closer look at single empirical studies with high research standards. In one study, an RCT of n = 61 depressed patients with comorbid child trauma and the effects of a mindfulness-based AAI with sheep was conducted (14). The treatment-as-usual (TAU) group underwent guideline-oriented treatment, and the AAI group received additionally a total of eight manualized animal-assisted sessions in a group setting over an 8-week period. AAI proved to be feasible, highly acceptable, and more effective than treatment as usual in preventing relapse after 1 year; however, statistical significance was scarce. A second AAI study explored the effect of the presence or absence of a therapy dog in the daily routine of inpatients with SUDs and comorbid mental disorders on social interaction as well as on positive and negative emotionality in a control group design. Significant differences in favor of the AAI were found in both the variables improvement of social interaction and emotionality (3). Critically, it is worth noting that there was no standardized procedure for the AAI intervention. Finally, in a series of studies with a pre–post crossover design, the effect of a single-session AAI intervention with a dog was examined. A significant reduction of negative emotions (anxiety) in severely mentally ill inpatients was demonstrated (24–26). Taken together, a group design with a single-session AAI intervention may be useful in improving emotionality in severely mentally ill patients. Due to their genetics, social structure, and sensitivity, sheep have excellent abilities to be used in the field of AAI. They are herd animals and therefore have social behavior skills. Humans can be integrated into their social structure if the sheep are given the opportunity to approach slowly. They provide security and relaxation, as they are very gentle and calm. Due to their sensitivity, mindfulness is necessary in dealing with sheep (27).

Abbreviations: AAI, animal-assisted intervention; CBT, cognitive behavioral therapy; EMA, ecological momentary assessment; FMI, Freiburg Mindfulness Inventory; INT, measurement directly after intervention; ISAAT, International Society for animal assisted Therapy; POST, post-measurement 1 week after intervention; PRE, pre-measurement before intervention; SCL-K-9, Symptom-Checklist short version; SIX, Objective Social Outcome Index; STAI-S, State-Trait Anxiety Inventory—state version; SUDs, substance use disorders; SWE, General Self-Efficacy Expectancy Scale, German version; TAU, treatment-as-usual.

The aim of the present pilot study was to examine whether a single session of AAI in a group setting with sheep can reduce negative emotions and improve positive emotions as well as mindfulness and self-efficacy expectancy. For this purpose, psychiatric inpatients with SUDs and comorbid mental disorders were studied directly before and 1 week after the intervention.

Materials and methods

Study design

A controlled, repeated-measures trial was conducted between January 2022 and March 2023 comparing TAU with a single-session animal-assisted intervention in addition to TAU (AAI) in inpatients with SUDs. Allocation to the control group (TAU) or AAI group was determined by the timing of inpatient treatment, as AAI sessions were scheduled in advance. To minimize selection bias due to the lack of an RCT design, exactly the same inclusion and exclusion criteria were applied to the AAI and TAU groups.

Ethical approval was obtained from the ethics committee of the University of Ulm (no. 13/22), including approval of the General Data Protection Regulation EU (GDPR) 2016/679. In accordance with the Declaration of Helsinki, participants were informed and provided written informed consent. The study was registered with the German Registry for Clinical Studies (DRKS00027539, date of first registration March 3, 2022).

Participants

Participants consisted of inpatients in a specialized ward for patients with SUDs and comorbid disorders in a hospital for psychiatry and psychotherapy in Germany. The patients in this ward had already completed the first phase of withdrawal treatment and received further CBT-based psychotherapy. Comorbid diagnoses cover the entire spectrum of mental illnesses. However, patients with comorbid personality disorders, trauma disorders, or attention-deficit/hyperactivity disorder (ADHD) were mainly represented, followed by patients with depression, anxiety, eating disorders, and even schizophrenia.

Inclusion criteria were age between 18 and 65 years, main diagnosis of SUDs, inpatient treatment for at least seven more days, capability for providing consent, and physical requirements such as standing and walking securely. Exclusion criteria were the presence of animal phobia, allergies, and aversion to specific animals (26). Patients in an acute mental crisis were also unable to participate, as were patients with insufficient language comprehension or mental retardation.

One Health Framework

The One Health Framework is an approach addressing human, animal, and environmental health (28). Quality standards for the use of animals in AAI are available (29–33) and also a risk assessment tool for (canine) assisted interventions (34). These standards were adopted.

The AAI took place at the Prinzenhof and was carried out by two certified professionals. PP is a specialist in animal-assisted education and support [certified International Society for animal assisted Therapy (ISAAT)] and the owner of the sheep; CN is a specialist in animal-assisted interventions (ISAAT) and a nurse and knows the participants from the clinical setting. The breed of the sheep was mountain sheep mix or Coburg fox sheep mix. They were partly bottle-fed and were therefore very people-oriented and trusting. The sheep live together as a flock at the Prinzenhof and were looked after and trained by PP. Sheep are animals that normally flee from predators and therefore also often from humans. The animals in this study were well accustomed to humans and did not show pronounced retreat behavior.

Before starting the intervention, the participants were supervised about the rules for handling sheep and the individual characteristics of the sheep to be taken into account. Participants were also informed that the intervention would be stopped immediately if there was a risk of the sheep's welfare being compromised. In addition, a so-called "protected" area was available to the sheep when working in either the open stable or the paddock. The sheep were conditioned to go to this area whenever they no longer wanted to participate in the intervention. Study participants were instructed not to enter this area and to respect any retreat behavior of the sheep. During the intervention, PP was primarily responsible for the care and supervision of the sheep and CN for the study participants.

AAI procedure

The AAI procedure lasted approximately 5 hours including travel time and took place at the farm "Prinzenhof" in Leutkirch, Germany (see also (35)). The additional costs per intervention group include a fee of 200 € for the "Prinzenhof", the costs for two professionals for 5 hours, and fuel costs. In case of good weather, the intervention was carried out in the sheep paddock, and in case of bad weather, in the open stable. Each AAI group consisted of four participants and four sheep. The AAI procedure was manualized and divided into seven sections.

1. *Observation of the farm owner's interaction with the sheep:* The farm owner (PP) was observed interacting with the sheep in the separated sheep paddock or the open stable. Her interaction with the animals served as a model of mindfulness and respect for the basic needs of the sheep.
2. *Introducing the sheep*: Still separated by a fence, the sheep were presented individually with names and specific characteristics. This made it easier for the participants to establish a connection with the sheep.
3. *Approach via feeding:* The sheep were fed by the participants over the fence, and the first physical contact took place.
4. *Approach via presence*: The participants sat down on prepared logs/chairs in the paddock/open stable. Contact

was established exclusively starting from the sheep moving freely. If a sheep joined a participant, it was allowed to make physical contact by petting, although the decision about the duration of the physical contact was up to the sheep. The persistence of contact was closely associated with the participants' mindfulness of the sheep's needs. In most cases, the partnerships between sheep and humans were established for the entire session at this stage on the initiative of the sheep.

5. *Experiencing competence and attachment:* The sheep were leashed by the respective participant, which represented a challenge, even if these sheep were used to it. The sheep then were led out of the paddock/out of the stable and a distance of approximately 200 m was walked together.
6. *Free walk-in mindful interaction:* Afterward, the leash was removed, and the sheep walked the rest of the course together with the participants. Sheep and participants formed a common flock, which allowed them to experience the connection between sheep and humans. The participants were given the opportunity to interact with the sheep and experience the trust that was built up between them.
7. *Farewell:* The sheep were returned to the paddock/stable, given water, and were farewelled by the participants. Over snacks and drinks, the participants conducted their feedback session.

Materials

As a primary outcome, the *State-Trait Anxiety Inventory—state version* (STAI-S (36)) was used. The test quality criteria, such as internal consistency, validity, and test–retest reliability, were satisfactory (Cronbach's alpha = .90). The questionnaire consists of 20 four-point Likert-scaled items (not at all, somewhat, moderately, and very much so). All items related to the absence or presence of anxiety, with 10 items representing positive emotions, e.g., "I feel secure", and 10 items representing negative emotions, e.g., "I am worried". To differentiate between these two expressions, a sum score for positive and one for negative emotions were calculated for the primary outcome.

For secondary outcomes, the *Freiburg Mindfulness Inventory short version* [FMI (37, 38)] was used. It comprises 14 items, which are assessed on a 4-point Likert scale (almost never, rarely, relatively often, and almost always). The items are worded positively and negatively. The measure has satisfactory test quality criteria. For measuring self-efficacy expectations, the *General Self-Efficacy Expectancy Scale*, German version [SWE (39)] was applied. The questionnaire consisted of 10 items with agreement from 1 to 4, resulting in a sum score from 10 to 40 (40). Good psychometric proprieties were reported (e.g., Cronbach's alpha = .92).

The SCL-K-9 (41) as the *short version of the Symptom-Checklist* [SCL-90-R (42)] was applied to assess the subjectively perceived symptom burden. The nine items were rated on a 5-point Likert scale according to symptoms in the last days. The SCL-K-9 is suitable as a screening instrument for the assessment of a wide range of psychopathological symptoms.

The *Objective Social Outcome Index* [SIX (43)] was used to assess social integration. The SIX consisted of four items: employment, accommodation, partnership/family, and friendship. The resulting score ranged from 0 to 6. Age, sex, diagnoses, and duration of inpatient stay data were extracted from the medical records after discharge.

Data on sociodemographic variables, degree of social integration, and clinical symptoms were collected to describe and compare the two study groups.

As a qualitative method, the participants were asked to freely write down ideas on the following question: *What did the animal-assisted intervention accomplish?*

The data were collected before the intervention (PRE) and 1 week after the intervention (POST). At PRE, the STAI-S, FMI, SWE, SCL-K-9, SIX, and sociodemographic data were collected. At POST, the STAI-S and FMI were SWE were measured again. Additionally, some questionnaires were given directly after the intervention while still on the farm (INT). Every participant first wrote down his/her ideas on the following question: *What did the animal-assisted intervention accomplish?* Afterward, the STAI-S, FMI, and SWE were presented.

Power calculation

For AAIs in psychiatric samples, effect sizes of d = .457 (26) and d = .869 (25) were reported for STAI-S over time. According to the case number calculation with G*Power 3.1 and based on the averaged effect size of both reported studies (d = .66), $\alpha = 0.05$, $\beta = 0.80$, one-sided testing and calculating t-test for dependent samples, n = 16 participants per group with full dataset were targeted. To compensate for possible drop-outs, n = 38 participants were to be recruited.

Statistical analysis

The analysis was performed using IBM SPSS 27®. Dichotomous variables were evaluated with the Chi^2 test. Normal distribution was tested using the Kolmogorov–Smirnov test. Group differences were analyzed for normally distributed data with t-tests for independent groups. Variance homogeneity was analyzed using Levene's test. For non-normally distributed data and ordinal scaled variables, group differences were tested using the Mann-Whitney U test.

To examine improvements in the two primary outcome sum scores of the STAI-S (negative and positive emotion) over time (PRE and POST), Wilcoxon tests were calculated separately for the AAI and TAU groups. In case of significant improvements observed in Wilcoxon tests, r resp. Cohen's d was calculated for effect size, with r = .1 resp. d = .2 representing a small effect, r = .3 resp. d = .5 representing a medium effect, and r = .5 resp. d = .8 representing a large effect (44). To examine the between-groups effects, Mann–Whitney U tests were calculated. Due to the significant improvements in AAI in contrast to the TAU group between PRE and POST, the results directly after the intervention (INT) were included in the analysis. Here, the Wilcoxon test (PRE vs. INT) and

Mann–Whitney U test (AAI vs. TAU) were calculated. In order to consider all three times (PRE, INT, and POST) in one analysis, a repeated-measures ANOVA was calculated. As Field (45) points out, even if the normal distribution assumption is violated (at INT in this case) or if the assumption of homogeneity of variance is violated (at PRE and POST in this case), ANOVA is considered to be a robust procedure and can therefore be used. The assumption of sphericity was checked using Mauchly's test of sphericity and was not violated.

For secondary outcomes, the assumption of homogeneity of variance was violated at SWE POST, FMI PRE, and POST; hence, corrections were applied. t-Tests for independent resp. dependent samples were calculated, as well as repeated-measures ANOVAs.

For qualitative analysis of participants' statements to the question "What did the animal-assisted intervention accomplish?" at INT, they were then analyzed in content using an alternating inductive and deductive procedure. The principle of openness prevailed. The statements relevant to the research purpose were paraphrased and then coded. The codes were then summarized into main and subcategories by consensus. The main categories and the identified subcategories as well as corresponding examples were presented.

Results

Comparability of groups

Of the n = 38 recruited patients, n = 20 were assigned to the AAI group and n = 18 to the TAU group. After excluding participants due to missing data, n = 19 participants in the AAI group and n = 17 participants in the TAU group were included in the analyses (see Figure 1). The groups did not differ significantly in age [t (34) = −0.871; p >.05], gender [Chi^2(1,36) = 0.000; p >.05], main diagnosis [Chi^2(3,36) = 1.730; p >.05], number of secondary diagnoses (U = 160.50; p >.05), and length of stay (U = 143.50; p >.05) in social integration, measured by the SIX (U = 127.00; p >.05), or in subjectively perceived symptom burden, measured by SCL-9-K [t (27.739) = 0.236; p >.05] (see Table 1).

Primary outcome

The STAI-S positive emotion sum score displayed a significant improvement over time (PRE and POST) for the AAI group (z = −2.447; p <.05) with a medium effect size (r = .397). However, there was no significant reduction over time in the STAI-S negative emotion sum score (z = −1.724; p = .085). There were no significant differences between the two groups (AAI vs. TAU), neither for PRE (negative emotions: U = 132.500; p >.05, positive emotions: U = 155.500; p >.05) nor for POST (negative emotions: U = 140.000; p >.05, positive emotions: U = 123.500; p >.05). When analyzing the difference between the time before and immediately after the intervention (INT) in the AAI group, the STAI-S negative emotion sum score was significantly reduced (z = −3.336; p <.05) with a large effect size (r = .548), and the STAI-S positive emotion sum score was significantly improved (z = −3.623; p <.001), also with a large effect size (r = .596). At INT, the two groups (AAI and TAU) differed significantly in both sum scores again with large effect sizes (negative emotions: U = 58.000; p <.001; r = .531; positive emotions: U = 39.500; p <.001; r = .634). In repeated-measures ANOVA, a significant time × group interaction was

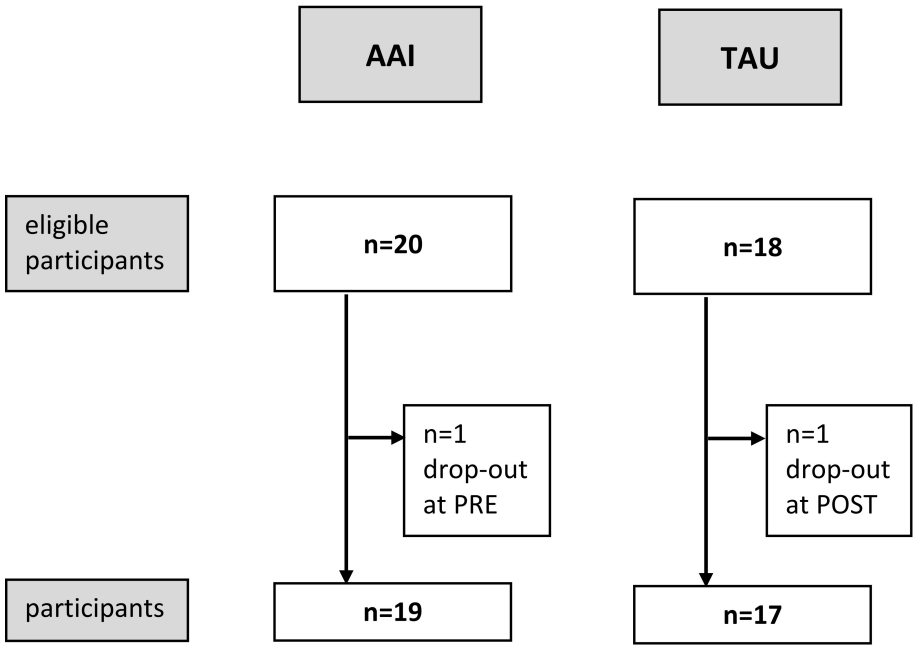

FIGURE 1
CONSORT for recruitment of both groups, animal-assisted intervention (AAI) and treatment as usual (TAU).

TABLE 1 Group comparison of animal-assisted intervention (AAI) and treatment as usual (TAU).

			AAI (n = 19)		TAU (n = 17)		p
Age		M (SD)	45.58	(14.51)	41.35	(14.56)	n.sign.[1]
Female		n (%)	9	(47.4%)	8	(47.1%)	n.sign.[2]
Main diagnosis: dependence syndrome	Alcohol	n (%)	14	(73.7%)	11	(64.7%)	n.sign.[2]
	Opioids	n (%)	1	(5.3%)	2	(11.8%)	
	Cannabinoids	n (%)	3	(15.8%)	4	(23.5%)	
	Multiple drugs	n (%)	1	(5.3%)	0	(0.0%)	
Number of secondary diagnoses		M (SD)	5.05	(2.37)	5.53	(3.50)	n.sign.[3]
Duration of stay (in days)		M (SD)	39.74	(18.86)	33.41	(7.57)	n.sign.[3]
Social integration (SIX)		M (SD)	2.84	(1.74)	3.47	(1.59)	n.sign.[3]
Symptom burden (SCL-9-K)		M (SD)	1.93	(1.13)	2.00	(0.59)	n.sign.[1]

SIX, Objective Social Outcome Index; SCL-9-K, subjectively perceived symptom burden.
[1]t-Test for independent groups.
[2]Chi^2 test.
[3]Mann–Whitney U test.

observed for the STAI-S negative emotion sum score [F(2,64) = 6.802; p <.01] and the STAI-S positive emotion sum score [F(2,66) = 11.968; p <.001] (see Figures 2, 3).

Secondary outcomes

In the mindfulness score (FMI), the AAI group improved significantly from PRE to POST [t(18) = −3.020; p <.01; Cohen's d = .637] in contrast to TAU [t(16) = −0.495; p >.05]. The two groups did not differ significantly at either PRE [t(32.212) = 0.134; p >.05] or POST [t(33.922) = −1.1483; p >.05]. When including INT in the analysis, a significant time × group interaction [F(2,68) = 7.261; p <.01] was observed. Both groups showed similar levels of mindfulness at PRE. While the TAU group remained at a stable level of mindfulness throughout, the AAI group improved in their mindfulness at INT, but this effect diminished at POST (see Figure 4).

The AAI group demonstrated also significant improvements in self-efficacy expectancy (SWE) at POST [t(18) = −4.095; p <.01; Cohen's d = .536], while the TAU group did not [t(16) = 0.982; p >.05]. Again, the groups did not differ significantly from each other at either PRE [t(34) = 0.899; p >.05] or POST [t(32.664) = −0.774; p >.05]. Also, a significant time × group interaction resulted

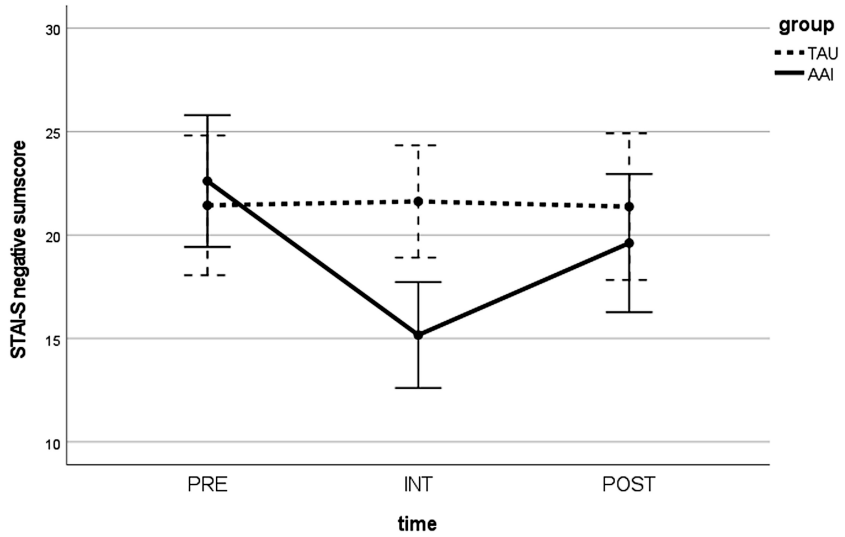

FIGURE 2
Values in the STAI-S positive emotion sum score over time (PRE, INT, and POST) for both groups (AAI vs. TAU). STAI-S, State-Trait Anxiety Inventory —state version; PRE, pre-measurement before intervention; INT, measurement directly after intervention; POST, post-measurement 1 week after intervention; AAI, animal-assisted intervention; TAU, treatment as usual.

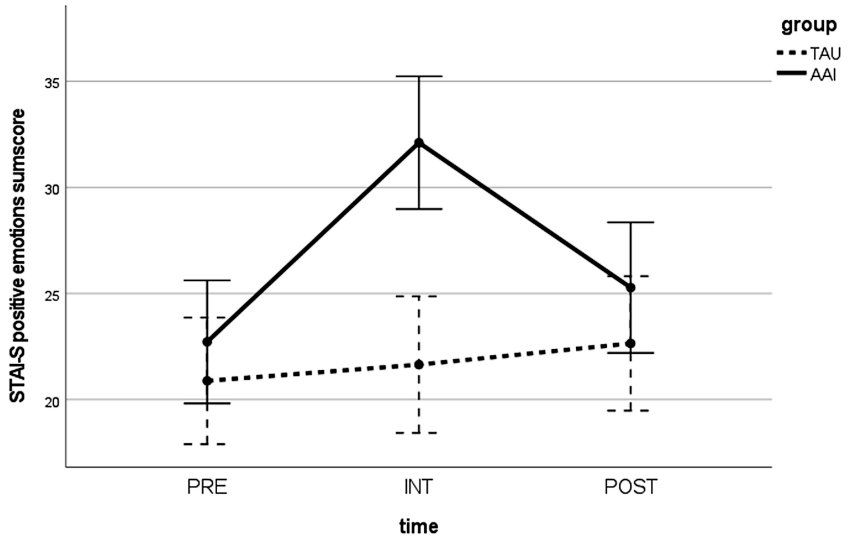

FIGURE 3
Values in the STAI-S negative emotion sum score over time (PRE, INT, and POST) for both groups (AAI vs. TAU). STAI-S, State-Trait Anxiety Inventory—state version; PRE, pre-measurement before intervention; INT, measurement directly after intervention; POST, post-measurement 1 week after intervention; AAI, animal-assisted intervention; TAU, treatment as usual.

[F(2,68) = 9.112; p <.05]. Both groups started at similar levels, with the TAU participants' scores changing little over time, while the AAI group's scores showed a peak at INT (Figure 5).

Qualitative analysis of participants' statements

The n = 78 statements made by the n = 19 AAI participants in response to the question "What did the animal-assisted intervention accomplish?" could be grouped into three categories. As Table 2 displays, the category "evoking positive valence" was mentioned most frequently, with a total of 53 statements. The participants verbalized mainly to have experienced some kind of mindfulness (n = 18), joy and fun (n = 10), and some sort of closeness (n = 8). The second main category is "decreasing negative valence" with n = 9 statements. The participants reported experiencing reduced rumination, prejudice, fear, and tension. In the last category with n = 16 statements, aspects of "positive valence in interacting with animals and nature" were included.

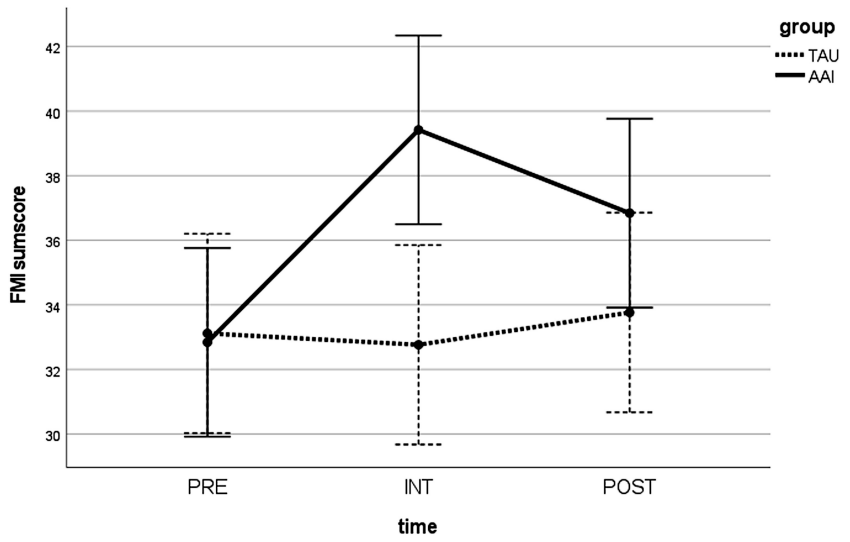

FIGURE 4
Values in the FMI sum score over time (PRE, INT, and POST) for both groups (AAI vs. TAU). FMI, Freiburg Mindfulness Inventory; PRE, pre-measurement before intervention; INT, measurement directly after intervention; POST, post-measurement 1 week after intervention; AAI, animal-assisted intervention; TAU, treatment as usual.

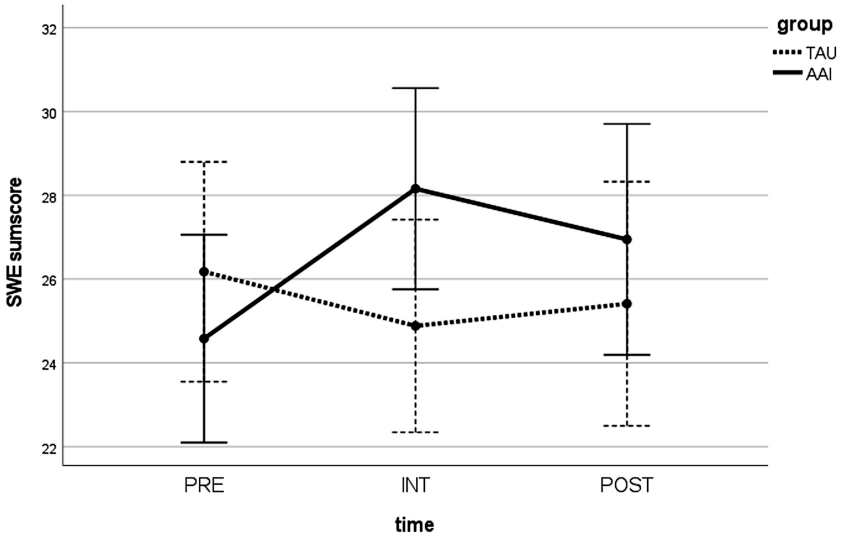

FIGURE 5
Values in the SWE sum score over time (PRE, INT, and POST) for both groups (AAI vs. TAU). SWE, General Self-Efficacy Expectancy Scale, German version; PRE, pre-measurement before intervention; INT, measurement directly after intervention; POST, post-measurement 1 week after intervention; AAI, animal-assisted intervention; TAU, treatment as usual.

TABLE 2 Categorized main categories and subcategories from the statements of the n = 19 participants of the AAI group to the question: "What did the animal-assisted intervention accomplish?".

Main category	Total N	Subcategory	N	Examples
Evoking positive valence	53	Mindfulness	18	Inner peace, calmness, more calm and more confidence, I was able to switch off completely, I feel a deep sense of reassurance, great serenity, clear mind
		Joy and fun	10	I had a lot of fun, great joy, it gave me joy
		Closeness, security, confidence	8	I felt closeness, I felt security, trust, confidence
		Satisfaction	5	Satisfaction, the sheep make me feel very comfortable
		Relaxation	3	I was a little more relaxed than usual, very relaxing
		Positive memories	3	Beautiful memories of my childhood, it was great and reminded me of my earlier career
		Others	6	I perceived my feelings more deeply, it has strengthened my self-esteem, on the whole, it was a great day and, great experience!
Decreasing negative valence	9	Reduced rumination	4	My thoughts and doubts were gone, other thoughts rather good but my thoughts still always wander (but not negatively TODAY)!
		Reduced prejudice	2	I was among people, something I usually avoid; I perceived my fellow patients differently
		Reduced fear	2	I had no fear, I was not afraid of sheep at all
		Reduced tension	1	My tension was less
Positive valence in interacting with animals and nature	16	Calming through animal interaction	6	The animals have something calming, mutual calming of humans and animals, stroking sheep was good
		Connectedness with animal/nature	3	Unity of human and animal, I felt connected with the sheep Toni, 100% closeness to nature
		Others	7	Feeling as if the sheep reflects the human, the sheep were kind and friendly, I have taken the sheep to my heart

Discussion

The feasibility of a single-session AAI with sheep as an enhanced CBT-based group therapy for SUDs with comorbid disorders was examined. The effect of reducing negative emotions and improving positive emotions as well as mindfulness and self-efficacy expectancy was investigated. In n = 36 participants, the primary outcome STAI-S positive emotions revealed a significant improvement with a medium effect size for the AAI group (r = .397). No effect was observed in the control group with treatment as usual. Thus, our AAI-enhanced CBT treatment was effective in improving positive emotions, which was still measurable 1 week after the intervention (POST). This is consistent with previous studies examining the effectiveness of AAI in changing emotionality in only a single session (24–26). In these studies, the effects were measured before and immediately after the intervention. For this reason, in addition to the reported results between PRE and POST, the effects immediately after the AAI (INT) were also examined. Here, the analyses yielded an even greater effect size for the changes in the positive (r = .596) and negative emotion sum scores (r = .548). In the secondary outcomes, mindfulness (FMI) and self-efficacy expectancy (SWE) also improved significantly between PRE and POST and again even more immediately after the intervention (INT). Taken together, our AAI-enhanced CBT approach seems to have succeeded in activating positive emotions on the one hand and reducing negative emotions on the other hand, both from a mindful, non-judgmental, accepting attitude. It also appears that the participants have succeeded in internally attributing the processes described above and therefore increasing self-efficacy expectancy. In SUDs associated with the presence of overwhelming negative emotions and deficits in emotion regulation (9), this AAI-enhanced CBT approach could help to improve therapeutic outcomes. The advantage could be that our approach promotes positive emotions and normalizes negative emotions instead of focusing only on emotion regulation, as opposed to CBT alone. This is also supported by the results of the qualitative analysis. Participants' statements about evoking positive valences (e.g., joy, closeness, mindfulness, contentment, and relaxation) and decreasing negative valences (e.g., anxiety, rumination, prejudice, and tension) can be seen in relation to the STAI-S results with its changes in positive and negative emotions.

The challenge for subsequent studies will be how to maintain the large effect seen in our and other reported studies (24–26) immediately after the intervention (INT) over a longer period of time. Schramm et al. (14) conducted therefore one booster session 3 months after finishing their 8-week program. Further studies will have to address the question of how the emotional moment of the AAI, which was experienced directly in the AAI, can be recreated and retrieved later. Imaginative techniques enriched with external representations of the sheep intervention are conceivable here. This could be realized, for example, through a guided imagination about the individual emotional moment of the AAI experience, anchored externally via a piece of sheep wool. Further research is needed to address this point.

Another issue to discuss is the effect of being outdoors in nature and how these circumstances impact participants. Nature-based interventions have proved to increase positive emotions and reduce negative emotions as well as anxiety and depression (46, 47). Our study also demonstrates the importance of the nature-based effect. The third category in the qualitative analysis included statements containing participants' interaction with animals and nature, which was valued positively. It must therefore ultimately remain open whether the interaction with sheep, the interaction with nature, or a combination of both is the basic principle for the reported results. Subsequent studies will have to investigate this.

There are several limitations. The main limitation is that we were not able to conduct a randomized controlled trial due to organizational feasibility. Instead, we used a non-randomized control group design. The advantage of this approach was the high clinical–ecological validity. An attempt was made to eliminate a possible selection bias by checking the comparability of the two groups. There were no differences in sociodemographic and clinical data, and thus, a comparability of the groups was assumed. However, the risk of a selection bias is high and cannot be excluded. In a subsequent study, the use of an RCT design is therefore strongly recommended, but a blinding strategy would not be possible in a clinical sample where the TAU group receives no further intervention.

A second limitation concerns the duration of the observation period, which was limited to a total of 1 week. This does not allow any statement about the effect of the AAI beyond this period. Even if such clear effects occurred with INT, statements about the further course of therapy and outcome as well as the further disorder progression are not possible. Perhaps ecological momentary assessments (EMAs) would be useful to more precisely capture and monitor the effect detected at INT. This could also happen over a longer period of time.

At last, the generalizability of the results found in our study is limited. The inpatients studied here were a highly selective sample of SUD patients with a high rate of comorbidity, a somewhat impaired level of functioning, and only a short duration of abstinence. Also, AAI results may vary in other farms and other species, such as dogs.

In conclusion, according to empirical studies, CBT has been the treatment of choice for SUDs alongside medication. However, given the high relapse rates of even successfully treated SUD patients, the question arises of how to enrich CBT. The activation of positive emotions and the simultaneous enabling of a non-judgmental perception and acceptance of negative emotions could provide a new treatment ingredient. Our concept of AAI-enhanced CBT follows this approach. As demonstrated, the AAI was successful in reducing negative emotions and improving positive emotions as well as mindfulness and self-efficacy expectancy immediately after the intervention. Unfortunately, the effect could not be fully maintained after 1 week. Nevertheless, the investigated AAI-enhanced CBT approach seems to be beneficial for emotion activation and tolerance, and therefore, it could be useful in the treatment of emotional dysregulation of SUDs, which is to date under too little consideration in pure CBT.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethikkommission der Universität Ulm. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

PS: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – original draft. CN: Conceptualization, Investigation, Writing – review & editing. CJ-E: Writing – review & editing. PP: Investigation, Writing – review & editing. ST: Writing – review & editing. CU: Conceptualization, Formal Analysis, Methodology, Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors would like to thank all study participants, humans and sheep. Thanks to the team of ward 2062 of the ZfP Südwürttemberg, Weissenau, for the dedicated support during this research work. Many thanks to PS for his support in creating the graphics. The authors would like to thank Tilman Steinert for being himself.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Psychiatry

TYPE Brief Research Report
PUBLISHED 24 October 2024
DOI 10.3389/fpsyt.2024.1476522

OPEN ACCESS

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RECEIVED 06 August 2024
ACCEPTED 01 October 2024
PUBLISHED 24 October 2024

CITATION
Schuck SEB, Zeiler CN, Stehli A, Steinhoff LA, Stokes RY, Jeffrey SE and Granger DA (2024) Acute salivary cortisol response in children with ADHD during psychosocial intervention with and without therapy dogs.
Front. Psychiatry 15:1476522.
doi: 10.3389/fpsyt.2024.1476522

Acute salivary cortisol response in children with ADHD during psychosocial intervention with and without therapy dogs

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Introduction: Children with Attention Deficit/Hyperactivity Disorder (ADHD) participated in a randomized clinical trial comparing animal-assisted intervention (AAI) to psychosocial treatment as usual (TAU). This brief report describes effects of AAI on acute HPA axis reactivity and regulation. Saliva was collected before, during, and after psychosocial intervention sessions with and without therapy dogs and later assayed for cortisol (ug/dL).

Methodology: Thirty-nine participants (n = 39) with ADHD, aged 7-9 years (79% male) provided saliva at 3 points during 90-minute sessions; (*i*) upon arrival, (*ii*) +20 minutes, and (*iii*) 15 minutes prior to departure, on 3 occasions across an 8-week intervention (weeks 1, 4, and 8). Cortisol slopes calculated within each session were compared across the intervention weeks to determine within subject and between group effect sizes. Spearman's correlations between baseline individual neurodevelopmental symptoms and in-session acute cortisol responses were also evaluated.

Results: No significant between group differences were observed in cortisol responsiveness at week-1. By week-4, in-session changes in cortisol were evident, with significantly greater decreases in the AAI group (Cohen's d = -.40). This pattern was also observed at week-8, with an even stronger effect-size (d = -0.60). Concurrent symptoms of autism were associated with the in-session acute cortisol response. Specifically, higher parent-reported symptom scores were associated with steeper decreases in cortisol across the session at week 1 (r = -0.42, p <.01) and week-8 (r = -0.34 p = .05). At week-8 this association was stronger in the AAI group (r = -0.53) versus TAU (r = -0.25), with Cohen's q = 0.413).

Discussion: AAI may influence acute HPA reactivity and regulation for children with ADHD. Concurrent symptoms of ADHD and autism may be related to individual differences in the nature of the effect. Implications of these findings for AAI as an alternative, or complementary intervention for ADHD are discussed.

Clinical trial registration: ClinicalTrials.gov, identifier NCT05102344.

KEYWORDS

attention deficit hyperactivity disorder (ADHD), animal assisted interventions, therapy dogs, cortisol (Cor), autism symptomatology, psychosocial skills intervention, school-based intervention

1 Introduction

Despite decades of research aimed to optimize outcomes for children with ADHD, the condition remains a significant public health problem. Pharmacotherapy (e.g., methylphenidate) is the mainstay of traditional medical intervention for ADHD, but side effects (insomnia, anorexia, movement tics) and treatment failures are common (1–3). Of particular concern in the recent years, children with ADHD are often prescribed medications during what are now recognized as critical periods of growth and there is emerging evidence that the dose and frequency of stimulant medicines has varying effects on growth, especially height (4). While the benefits of medication treatments are well-established and oftentimes an integral component of optimal outcomes, it is not surprising that parents and mental health professionals continue to seek complementary and alternative treatments for children with ADHD. Our previous research found AAI to be effective in reducing ADHD symptoms and improving social skills and self-perception (5–7). While we demonstrated efficacy, the underlying mechanism of effect is unknown; a critical knowledge gap needed to increase the acceptability and accessibility of this integrative health care strategy. The present study examines a candidate bio-social mechanism which may influence outcomes of AAI and seeks to better identify individual differences in these biological responses thought to moderate key outcomes.

The suspected mechanisms by which Human Animal Interaction (HAI) is theorized to influence behavior change are diverse. Studies have reported physiological responses to animal interaction indicative of reduced stress as measured by decreased Hypothalamic Pituitary Adrenal axis (HPA) activity as measured by salivary cortisol levels; reduced blood pressure; and decreased Autonomic Nervous System (ANS) activity as measured by increased heart rate variability (HRV) (8). Recent studies have found that AAI (with dogs) lowered salivary cortisol in children (9, 10). One possibility is that these physiological responses reflect a calming-stress reducing effect of AAI and may improve access to curriculum and therapeutic activities (11). Despite these advances there remain several untested alternative rival hypotheses.

The role of individual differences, both biological and psychosocial, and the plausible influences of those differences on response to AAI is a critical area for evaluation. Of interest, a single nucleotide polymorphism (sNP) in the oxytocin receptor gene, *OXTR* rs53576 has long been associated with human social interaction styles (12, 13). This polymorphism, which involves a guanine (G) to adenine (A) substitution, has been extensively studied and those individuals with the A-carrier variant (AA and AG versus GG) may be less sensitive to the social environment (13). A notable finding indicates the quality of children's interaction with their family pet is moderated by this genotypic difference, in that A-carriers were more engaged with petting their dogs (14). This finding is important as it provides the first evidence for individual genotypic differences that may contribute to differential responses to AAI, particularly for those children who may have social skills deficits.

While long considered a disorder marked by deficits in skills of executive functioning (EF), individuals with ADHD oftentimes are most impaired by social difficulties including oppositionality and a lack of understanding social context. Many will present with co-occurring neurodevelopmental and disruptive behavior disorders, including Oppositional Defiant Disorder (ODD) and Autism Spectrum Disorder (ASD). Specifically, nearly half of individuals with ADHD present with (ODD) (15) and the lifetime prevalence of ADHD in individuals with ASD is estimated at about 40% (16). Of note, a recent review indicates that these disorders have overlapping deficits in skills of executive function (EF) and yet very different psychosocial trajectories (16). Considering the complexity of ADHD, exploration of how these individual differences may moderate response to AAI is indicated. It is reasonable to suspect that differences in response to AAI may be linked to individual differences among children with ADHD.

Deficits in skills of EF, particularly sustained attention and inhibition or self-regulation are associated with differences in activation of and dysregulation of the HPA axis, which is typically measured by cortisol levels. Of note, the secretion of cortisol follows a diurnal cycle and Isaksson et al. (17), reported that children with ADHD, aged 10–17 display lower levels of salivary cortisol in the morning and evening when compared to controls (17). An association

of downregulated HPA axis and ADHD fits with theories that regard impairment from ADHD because of under-arousal of the dopaminergic systems (18). Lee, Shin, & Stein (19) studied salivary cortisol response to a stressful stimulus in children with ADHD and found a relationship between increased cortisol levels after the stressor and variability in response time. Taken together these works provide evidence that children with ADHD display higher physiological reactivity to stressors, in line with well-established deficits of self-regulation and inhibition. Studies in typical populations and in children with ASD have linked HAI with acute reductions in cortisol and lowered diurnal patterns in response to AAI (8, 20). It is not known, however, if AAI acts on HPA axis similarly in individuals with low baseline HPA axis activity such as children with ADHD. If so, this reduction could contribute to beneficial outcomes.

In our earlier work, as early as 2 weeks into intervention participants in the AAI group were found to have significant treatment gains compared to the treatment as usual group (TAU) (5). Consistent findings have been reported across different populations of children and diverse animal species (21–23). These findings support proof of the concept that AAI is effective for children with ADHD. None of these studies, however, directly investigated mechanisms of action. Exploration of theoretically indicated mechanisms suspected to elicit benefit from AAI in children with ADHD is indicated. Considering the physiology of ADHD, the hypothetical mechanisms of action in AAI described in other populations may be different in this population. It is not clear that AAI elicits the same physiological responses in children with ADHD as it does in other populations. Exploration into the potential role of HPA axis reactivity and other individual differences on AAI outcomes may inform both practices and policies.

2 Method

2.1 Study design

This study was approved by the local university Institutional Review Board (IRB) as well as the Institutional Animal Care and Use Committee (IACUC). This study employed an exploratory parallel group randomized controlled trial study design and utilized a *multi-method and multi-source* assessment protocol. Parents or legal guardians of all participants provided signed consent for their minor to participate and all child participants provided written or verbal assent. After completing consent and meeting eligibility criteria, participants were randomly assigned to one of two intervention conditions, group psychosocial skills training treatment as usual (TAU; n = 19), or (2) the same group treatment assisted by therapy dog/handler dyads or animal assisted intervention (AAI; n = 20).

2.2 Participants

Thirty-nine (39) children, ages 7 to 9 (79% male) were randomly allocated to intervention conditions (TAU or AAI) and completed their respective group intervention across six (6) cohorts over two (2) years. Eligibility was determined utilizing a multi-gate screening procedure described in our earlier work including a screening for history of stimulant treatment, animal abuse, fear of dogs, and allergy to dogs. All participants met research criteria for combined-type attention deficit/hyperactivity disorder (ADHD). Individuals meeting research criteria for autism spectrum disorder (ASD), as measured using the Kaufman-Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS) were excluded (24). Additionally, participants had at least an estimated full-scale IQ of 80 as determined by the Wechsler Abbreviated Scale of Intelligence (25). Finally, all participants were either medication naive or had experienced at least a 6-week wash out of any stimulant medications prior to consent and screening.

2.3 Therapy dog/handler dyads

Two (2) volunteer therapy dog/handler dyads were selected to participate over the course of the study after completing a screening process and interview described elsewhere (26). Both dyads were registered through Pet Partners, a volunteer therapy animal organization. Pet Partners requires that all dog/handler dyads participate in a rigorous initial qualifying process and are regularly evaluated using a rigorous set of standards for safety, behavior, and conduct. Standards for humane involvement of animals and their welfare during AAI set forth in the International Association of Human Animal Interaction Organization's white paper (27) were also adhered to throughout the study to best ensure the safety and general welfare of the dogs. The study was assisted by a 5-year-old, male Golden Retriever, and his volunteer female hander (aged 60) and a 3-year-old, female English Cream Retriever, and her volunteer female handler (aged 59). Handlers participated throughout the AAI to ensure the safety and comfort of the therapy dogs. To prevent fatigue, the duration of the dog involvement was limited to 90-minutes of the two-hour sessions.

2.4 Intervention models

Conventional treatments for children with ADHD include stimulant medications, behavioral parent education, and psychosocial skills training interventions (SST). A manualized social skills intervention with and without the assistance of volunteer therapy dog/handler dyads was developed in our prior work was adapted for this pilot study (5). The Positive Assertive Cooperative Kids (PACK) model targets the reduction of symptoms of inattention, hyperactivity, and oppositional behavior and the development of self-awareness, self-regulation, and pro-social behavior (6). The PACK model can be implemented with (AAI) or without (TAU) the assistance of volunteer therapy dog dyads. Participants in the TAU condition followed the same protocol as the AAI, but activities utilized realistic puppets in lieu of therapy dogs. In the evidence-based model, six children attended group social skills training sessions twice weekly over a 10-week intervention with or without three accompanying therapy dog dyads. For the aims of the current pilot study, the intervention was reduced to be delivered once weekly across an 8-week intervention. Furthermore, due to

COVID-19 global pandemic and government issued safety protocols, recruitment and participant attendance was compromised for this pilot. As such modifications were made to the original PACK model to allow for four to five children per group and one or two volunteer dog/handler dyads accompanying one moderator and two behavior counselors.

Participants in each group were taught the same social skills (i.e., assertion, accepting, ignoring, etc.) complemented with lessons on humane treatment, animal welfare, and safe interactions with dogs. In the AAI group, participants were also instructed on how to teach and deliver basic commands for dogs (i.e., sit, down, stay), while the TAU group practiced teaching skills utilizing telling stories or sharing about themselves with their peers. Participation in the lessons was supported by a token economy system delivered by the two behavior counselors. Treatment fidelity across sessions and weeks for both conditions was supported by utilizing a manualized intervention checklist observation measure and post-session intervention team debriefing each week.

2.5 *In-vivo* saliva collection

To explore HPA axis activity, an indicator of an individuals' stress response, saliva was collected from all participants utilizing Salimetrics® SalviaBio Oral Swab (SOS method). All participants provided saliva samples at each of three time points during two-hour after-school intervention sessions, (*i*) upon arrival at approximately 4:00 p.m., (*ii*) +20 minutes, and (*iii*) 15 minutes prior to the end of the lesson at approximately 5:20 p.m. Of note, parents were instructed to ensure that their children refrain from eating at least 30-minutes and preferably one hour prior to arrival to the sessions. During collection procedures, participants were directed to remain seated in a chair for two minutes with the oral swab inserted in their mouth. After the two-minute period, participants were directed to spit the swab into a uniquely labeled vial corresponding with their participant identification number. Each vial was immediately placed in frozen storage at -20° Celsius. Time stamps were recorded for the times when: a) the swab entered the child's mouth, b) the child spat the swab into the vial, and c) the vial was put into placed into frozen storage. This collection and storage procedure was repeated on three total occasions across an 8-week intervention (at weeks-1, 4, and 8). Saliva samples were then tested for cortisol using a commercially available immunoassay specifically designed for use with saliva at the Salimetrics Technology and Development Center (Carlsbad, CA). The assay had a lower limit of sensitivity of.007 ug/dl and range up to 3.0 ug/dL with average inter and intra-assay coefficients of variation less than 15 and 5%, respectively.

3 Analysis

3.1 Salivary cortisol

Due to design factors such as reduced subgroup sample size, non-normally distributed measures, repeated measurements and the potential for relatively high variability, a combination of non-parametric statistical analyses and effect sizes were employed. This allowed both statistical evaluation of the intervention and exploration of clinical significance as well as effect modifiers. Acute HPA axis response to intervention conditions during sessions was measured by calculating three slopes for change in Cort (ug/dL) among the three in-session time points for all participants (1); from arrival to +20 minutes (*i* to *ii*) (2), from +20 minutes to 15 minutes prior to lesson end (*ii* to *iii*) and (3) from arrival to 15 minutes prior to lesson end (*i* to *iii*). These calculations were repeated on three occasions across the intervention period, at weeks-1, 4, and 8. Concentration values (ug/dL) at each timepoint were also examined. Average slopes and concentrations were compared within-subject (over time) and between groups utilizing repeated measures analyses (Wilcoxon sign rank tests for paired comparisons) and effect size calculations (28).

3.2 Individual differences

The individual neurodevelopmental symptoms of ADHD, Oppositional Defiant Disorder, Autism Spectrum Disorder, reading skills and intellectual skills were measured at baseline utilizing a battery of assessment tools Attention Deficit Hyperactivity Disorder Rating Scale (29), Autism Syndrome Rating Scale (30), Test of Word Reading Efficiency (31), and the Wechsler Abbreviated Scale of Intelligence (25). The relationship between each of these measures and acute sCort in-session response were explored utilizing Spearman's *r* correlation coefficients within each group (AAI and TAU). Comparison of correlation coefficients between groups were performed using effect sizes (28).

4 Results

At week-1, there were no significant group differences in any of the three sCort slopes measured across the 90-minute lesson session (p = .727, p = .834, p = .646). By week-4, group differences in the first cortisol slope upon arrival (ΔCort arrival to +20 minutes) were revealed, with the dog group demonstrating a steeper decrease in cortisol on average ($\sum_{AAI}$ = -0.0014, $\sum_{TAU}$ = -0.0003). This difference produced a moderate effect size (*d* = .547). and approached statistical significance on non-parametric tests (Wilcoxon *S* p =. 0.0562. At week-8 this trend was still present ($\sum_{AAI}$ = -0.0010, $\sum_{TAU}$ = - 0.0004), but the effect was smaller (*d* = -.386, *p* = 0.365). Of note, for all participants mean values of sCort were relatively high at arrival on week-1 (0.1813 μg/dL) with a greater magnitude of reduction within 20-minutes for the AAI group. The effect size for this reduction was medium (*d* = .468) though not statistically significant (*p* = .376). This trend was consistent over time (See Figure 1). At week-1, for all participants, symptoms of autism, as measured by parent reported ASRS total *t*-score at enrollment, were significantly correlated with the overall in-session slope (arrival to 15 minutes prior to departure) (*r* = -0.3736, *p* = .025). Of note, the arrival slope at week-1 (arrival to +20 minutes) was moderately correlated with the ASRS (*r* = - 0.4756, *p* = .003) and this correlation seems to be contributing to the overall in-session correlation. Specifically,

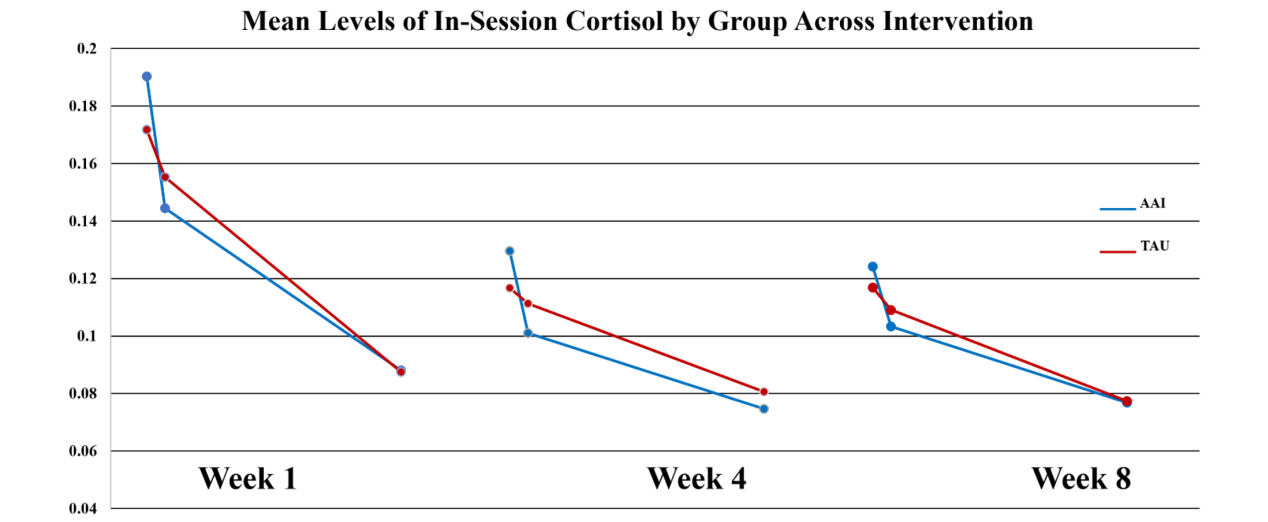

FIGURE 1
Mean levels of in-session cortisol by group across intervention.

higher *t*-scores on the ASRS were associated with steeper decreases in sCort across the session (See Figure 2). At week-8, the overall in-session slope (arrival to 15 minutes prior to departure) correlation remained significant for both intervention groups (r = -0.3685, p = .035). Moreover, in week-8, the relationship was larger in the AAI group (r = -0.508) versus TAU (r = - 0.2144) yielding a medium effect size (Cohen's q = 0.376) (See Figure 3). No other individual differences in screening measures were revealed (i.e., ADHD or ODD symptom severity, IQ, gender, age, etc.)

5 Discussion

Results suggest this AAI, adapted from the manualized intervention protocol employed in our earlier work, lowers in-session HPA axis activity in children with ADHD. This response provides evidence that AAI may play a role in improving treatment outcomes of more traditional psychosocial interventions. Additionally, these findings suggest that even in reduced 'doses' interacting with volunteer therapy dog results in measurable physiological responses associated with reduced stress.

5.1 The role of individual differences

The role individual differences may play in the response to psychosocial interventions and to AAI have been discussed in the literature (14, 32). Of interest, in our findings, is the role of co-occurring symptoms of autism in physiological responses to AAI among children with ADHD who did not meet diagnostic criteria

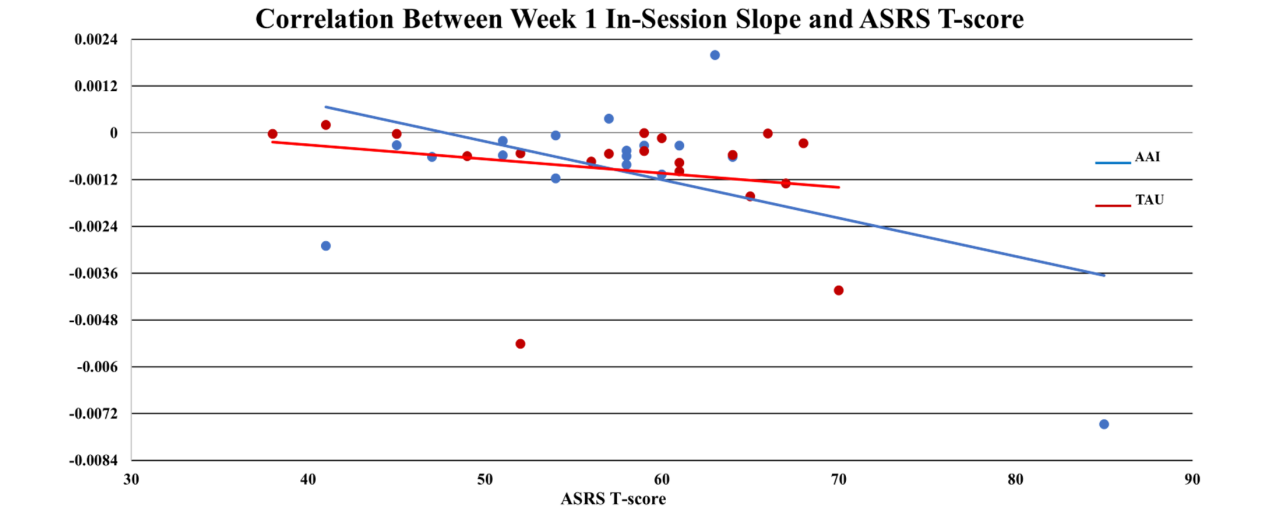

FIGURE 2
Correlation between week 1 in-session slope and ASRS t-score.

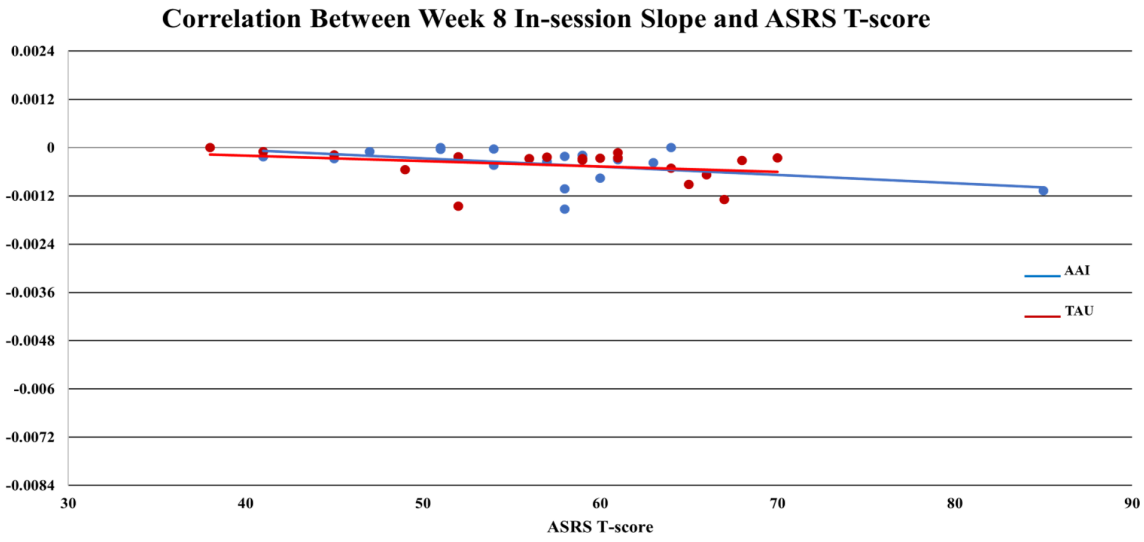

FIGURE 3
Correlation between week 8 in-session slope and ASRS t-score.

for ASD. Specifically, we found a moderate correlation in the initial reduction in cortisol during the first 20 minutes of the intervention and symptoms of autism, suggesting that those individuals with more social impairment may particularly benefit from the accompaniment of a therapy dog during evidence-based psychosocial intervention. It has been shown that animal assisted activities (AAA) are effective in improving social functioning in young children with ASD (33). Considering the present results, and the well-established overlap of symptomatology in children with ADHD and ASD, we suspect there may be a similar mechanism of action underlying favorable response to AAI.

5.2 Biological sensitivity to stress and the social context

Considering the complexity of ADHD presentation, it is reasonable to surmise that children with ADHD may be more, or less, biologically sensitive to the context in which therapeutic interventions are delivered. We suspect that those who are the most biologically sensitive to negative experiences and less sensitive to social feedback are also the ones who are the most likely to benefit from an AAI enriched treatment. A closer examination of biological responses to AAI for children with ADHD could provide information about what profiles of children are most likely to benefit from AAI. It may be that some children with ADHD do not present with the same degree of biological sensitivity to the context in which psychosocial interventions are delivered but that others are particularly sensitive and stand to benefit more from a treatment enriched by AAI.

This work contributes to a growing body of evidence supporting the efficacy of involving animals in activities and interventions for special populations of children. Biometric data collected from the present study contributes to field of HAI research by enhancing our understanding of the biosocial mechanisms by which AAI can improve outcomes for children with ADHD as well as yields important findings regarding individual differences in response to AAI. This work also demonstrates that, even in lower doses than previously implemented, AAI still yields meaningful clinical improvement. Additionally, this study establishes the feasibility of conducting salivary science methods during AAI for this population.

6 Future directions & limitations

There is limited understanding of the socio-emotional and physiological mechanisms by which interaction with animals has therapeutic benefit for this population; specifically, when and for whom AAI with therapy dogs may be most effective. This pilot work indicates the role of stress response to AAI may play an important role in understanding how this population benefits from AAI. Without delineation of the mechanisms of AAI in this population, the development of rigorous empirical studies is hampered. This work suggests cortisol, a biomarker for HPA axis activity, is a viable candidate mechanism involved in response to AAI. Next steps include the need to explore the relationship of this biomarker and social outcomes of self-regulation and self-awareness, key components of executive function. Future studies, including larger trials including participants with common comorbid neurodevelopmental and behavioral disorders, to examine the potential role of this biomarker in AAI are warranted to better understand the generalizability of this finding. Specifically, results regarding the role of individual differences in response to AAI, especially a more in-depth exploration of complex symptom presentation around social competency is indicated.

The sample size of this exploratory study limits the generalizability of this work. Of note, while designed as an exploratory pilot, with a targeted sample size of 45-48, the intervention protocol was delivered during the global COVID-19 pandemic which compromised enrollment and attrition. Despite the limitations of the study,the results suggest, a further

examination of other biological and psychosocial factors related to stress response, particularly ANS reactivity may contribute to our understanding of which other mechanisms may contribute to AAI response. Candidate biomarkers (salivary alpha-amylase and Heart Rate Variability) were also collected in this trial and will be examined. Additionally, parent ratings of prosocial behaviors (social skills) and the quality of observed child-dog interaction during AAI sessions was also collected and will be examined.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study involving human subjects was approved by the University of California, Irvine Institutional Review Board (HS20206069). This work was also approved by the local Institutional Animal Care and Use Committee and was designated as not being considered animal research. This study was conducted in accordance with the local legislation and institutional requirements. Written informed consent for all participants was provided by legal guardians/next of kin and assent was provided by participants.

Author contributions

SS: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Formal Analysis, Conceptualization. CZ: Writing – review & editing, Writing – original draft, Project administration, Data curation. AS: Writing – review & editing, Writing – original draft, Methodology, Formal Analysis. LS: Writing – original draft, Data curation, Project administration. RS: Writing – review & editing, Project administration, Data curation. SJ: Writing – review & editing, Writing – original draft, Data curation. DG: Writing – review & editing, Writing – original draft, Methodology, Conceptualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was supported by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) and through the Mars-WALTHAM® partnership. (Grant #R21HD103422).

Acknowledgments

We acknowledge special thanks to Ron Kotkin and Aubrey Fine for their significant contributions to the development of this intervention. Thank you to the many research assistants, many of whom began remotely during the pandemic, especially Peyton Groves. A special thanks to Pet Partners, our volunteer dyads, for their time and assistance with this project. Thank you to our Licensed Marriage & Family Therapist, Patty Ramsey for sticking with this project during a turbulent time. And, most importantly, we greatly appreciate the children and their families for participating.

Conflict of interest

DG is Chief Scientific and Strategy advisor at Salimetrics LLC and Salivabio LLC. These relationships are managed by the policies of the committees on conflict of interest at the JHU School of Medicine and UCI.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be constructed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 11 February 2025
DOI 10.3389/fpubh.2024.1450216

OPEN ACCESS

EDITED BY
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RECEIVED 17 June 2024
ACCEPTED 30 December 2024
PUBLISHED 11 February 2025

CITATION
Zhang Y, Qiu S, Guo VY, Chen W, Han X and Yang W (2025) Association of only-child status and household pet ownership with attention-deficit/hyperactivity disorder among Chinese preschool children: a population-based study.
Front. Public Health 12:1450216.
doi: 10.3389/fpubh.2024.1450216

Association of only-child status and household pet ownership with attention-deficit/hyperactivity disorder among Chinese preschool children: a population-based study

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Background: The associations of only-child status and household pet ownership with the risk of attention-deficit/hyperactivity disorder (ADHD) are inconclusive, and the joint effects of only-child status and household pet ownership on ADHD have not been thoroughly investigated.

Methods: A population-based study was conducted in 2021 involving preschool children aged 3–6 years attending kindergartens in Longhua District, Shenzhen, China. Parents were invited to complete questionnaires providing information on socio-demographic and family-environmental factors. ADHD symptoms were assessed using the 26-item Swanson, Nolan, and Pelham Rating Scale as reported by parents.

Results: This study included 63,282 children (mean age: 4.86 ± 0.85 years, 53.6% boys), representing 72.6% of all preschool children in this district in 2021. Among them, 34.4% were only-child and 9.6% were identified as having ADHD. Only-child status was associated with an increased risk of ADHD [adjusted odds ratio: 1.30 (95%CI: 1.23–1.38). Compared to children without a pet (cats or dogs) at ages 0–3 years, pet ownership at ages only 0–1 year, only 1–3 years, and both ages were associated with increased odds of ADHD: 1.59 (1.30–1.95), 1.58 (1.28–1.93), and 1.66 (1.42–1.92), respectively, after controlling for potential confounders. A significant interaction between pet ownership at only 1–3 years and only-child status was observed (adjusted P for interaction = 0.028). Similar findings were observed when the analyses were performed separately for boys and girls.

Conclusion: Both only-child status and household pet ownership are associated with an increased risk of ADHD; however, the detrimental effect of pet ownership appears to be mitigated among only children when pet exposure occurs at ages 1–3 years, providing new insight into reducing family-related risk factors of ADHD.

KEYWORDS

attention-deficit/hyperactivity disorder (ADHD), preschool children, only-child status, pet ownership, joint effect

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is the most prevalent neurodevelopmental disorder, affecting approximately 7.2% of children globally (1, 2). ADHD is characterized by hyperactivity, inattention, and impulsivity at developmentally inappropriate levels (3), leading to impaired education achievement, poor peer relationships, and an increased risk of other mental health disorders (4–6). Although ADHD is largely genetically inherited (70%), environmental factors also play a significant role in its etiology (7). Consequently, there is an urgent need to identify potential modifiable environmental risk factors for targeted prevention.

Siblings have been suggested to play a crucial role in children's neurodevelopment, including the occurrence of ADHD (8–13). However, the impact of only-child status on ADHD risk remains inconclusive, and studies in this area are limited. Only children may experience distinct developmental environments compared to those with siblings (e.g., the absence of sibling interaction and increased attention from family members), which could potentially influence ADHD risk. A previous study involving 161 pairs of ADHD cases and non-ADHD controls revealed that being an only child was independently associated with an increased risk of ADHD diagnosis among Chinese children (11). Conversely, null findings were reported in the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) study ($N = 13{,}488$) (12). In China, the one-child policy was in effect for approximately 40 years; although it was abolished in 2016, many families still have only one child. Given the significant burden of ADHD on individuals and families, further research is needed to elucidate the relationship between only-child status and ADHD, especially in light of policy changes in China.

In addition to only-child status, factors such as parental age, educational attainment, household income, and pet ownership collectively shape children's upbringing environments. Among these, pet ownership has become increasingly common and may influence children's neurodevelopment (13–16). The emotional benefits of pet attachment, such as providing emotional comfort, reducing stress, and fostering compassion and social skills, may contribute to neurodevelopmental advantages (14–20), particularly for only children lacking companionship. However, pets can also introduce environmental toxins (e.g., pesticides) into the home (21), which might increase the risk of ADHD (22). Currently, studies investigating the impact of early-life pet exposure on ADHD are limited, and existing findings remain inconsistent, with both positive and negative associations reported (17, 23). Therefore, it is essential to explore the impact of pet ownership on the risk of ADHD in children and whether pet companionship can mitigate the impact of being an only child.

Therefore, this population-based study investigated the impact of only-child status, pet ownership, and their interaction on the risk of ADHD in Chinese preschool children. Our findings aim to enhance the understanding of ADHD and help identify vulnerable children for targeted prevention.

Methods

Study design and participants

This study utilized data from the 2021 wave of the Longhua Child Cohort Study, an annual population-based survey that evaluates the impact of family environment on children's neurodevelopment (24, 25). In this survey, parents of participating children were invited to complete a structured questionnaire covering the socio-demographic information, children's prenatal and early-life exposures (ages 0–3 years), and their neurodevelopment. The Chinese version of the questionnaire was administered via a mobile app specifically developed for this survey. A total of 87,081 children aged 3–6 years from 234 kindergartens were approached, and 69,633 participants completed the questionnaires which were filled out by their parents, representing 80.0% of preschool children in Longhua District. After excluding twin-born children and participants with missing or invalid data on child number, pet ownership, or other study variables, the final analysis included 63,282 children (Figure 1). The study was approved by the Ethics Committee of the Shenzhen Longhua Maternity and Child Health Care Hospital, and informed consent was obtained from all participants.

Only-child status and pet ownership

Parents were asked to report the number of children in their family. Pet ownership was assessed through two self-reported questions: (1) "Did you own a pet cat or dog when this child was aged 0–1 years?" (2) "Did you own a pet cat or dog when this child was aged 1–3 years?" Responses to both questions were recorded as "yes" or "no." Based on the answers, children were categorized into four groups: never owned a pet during ages 0–3 years, owned a pet only during ages 0–1 year, owned a pet only during age 1–3 years, and owned a pet during both age ranges.

Measurement of ADHD symptoms

ADHD symptoms were measured using the 26-item Swanson, Nolan, and Pelham (SNAP) Revision 4 (SNAP-IV) scale, which has been validated in the Chinese population and is widely used for assessing ADHD symptoms (26). The SNAP-IV scale includes two subsets of ADHD symptoms (inattention and hyperactivity/impulsivity) based on DSM-IV criteria, as well as a subset for opposition/defiance. Each item is scored from '0' (not at all) to '3' (very often). Subset scores were calculated by summing the item scores, and children were classified as having borderline problems in inattention or hyperactivity/impulsivity if their respective subset score exceeded 13. The SNAP-IV scale

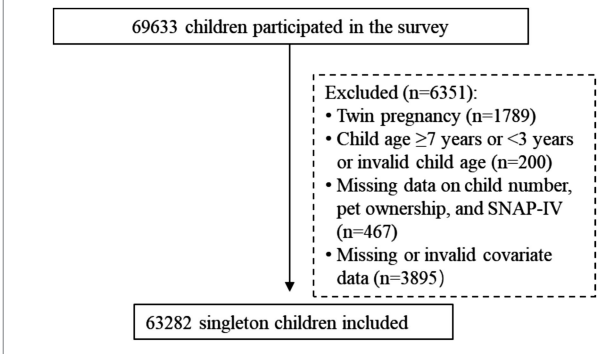

FIGURE 1
Participant selection.

demonstrated excellent reliability with a Cronbach's α coefficient of 0.92 in this study.

Covariates

Data on child age, sex, gestational age, mode of delivery, parental age and education background, household income, and marital status of biological parents were collected through a self-reported questionnaire completed by the children's parents. Educational background was categorized into four levels: (1) primary or middle school, (2) high school, (3) college, and (4) graduate. Household income was divided into four groups: (1) <10,000 RMB/month, (2) 10,000–20,000 RMB/month, (3) 20,001–30,000 RMB/month, and (4) >30,000 RMB/month. Marital status was classified as married and unmarried/divorced groups. The mode of delivery was classified as vaginal or cesarean.

The 5-item Family Adaptation, Partnership, Growth, Affection, Resolve (F-APGAR) questionnaire was used to assess participants' satisfaction with family functioning based on parameters of adaptability, partnership, growth, affection, and resolve. Responses were recorded on a 3-point scale (0 = hardly ever, 1 = sometimes, 2 = almost always), with a higher score indicating greater family support and better functioning (27).

Statistical analysis

Data were presented as mean ± standard deviation (SD), number (%), or median (interquartile range) as appropriate. T-test, Mann-Whitney U-test, or chi-square test were used to compare characteristics between children with and without ADHD symptoms. Logistic regression analyses were performed to assess the associations between only-child status, pet ownership, and ADHD risk. Initially, associations were evaluated in a crude model, followed by a multivariate model adjusted for social-demographics and family-environmental confounders, including child age and sex, parental age, marital status, education, income, and family functioning. To further explore the interactive effects of pet ownership and only-child status on ADHD risk, children were divided into eight groups based on these two variables, and logistic regression was performed with group 1 (non-only children without pet ownership) serving as the reference group. Considering that ADHD is a sex-biased disorder, logistic regression analyses were further performed separately for boys and girls to evaluate potential sex-specific associations.

All analyses were performed using R software (version 4.2), with statistical significance set at a p-value of <0.05 (two-sided).

Results

The characteristics of study participants are shown in Table 1. The mean age of the children was 4.86 ± 0.85 years, with 53.6% being boys. Among these children, 60,316 (95.3%) reported no pet ownership during ages 0–1 or 1–3 years. In contrast, 744 (1.2%) reported pet ownership only at ages 0–1 year, 786 (1.2%) only during ages 1–3 years, and 1,436 (2.3%) during both age ranges. Overall, 21,751 (34.4%) of the children were only children, and 6,049 (9.6%) were identified as having ADHD according to the SNAP-IV scale. Compared to those without ADHD, children with ADHD were younger, more likely to be boys, and had parents who were younger, less educated, and more likely to be unmarried or divorced. In addition, these families reported lower household income and family functioning. The gestational age and mode of delivery of these children did not differ significantly between groups. Pet ownership and only children were more prevalent among children in the ADHD group.

As shown in Table 2, being an only child was significantly associated with increased odds of ADHD [odds ratio (OR) = 1.42 (95%CI: 1.34–1.49), $p < 0.001$]. This association remained significant [adjusted OR = 1.30 (95% CI: 1.23–1.38), $p < 0.001$] after adjustment for confounders including child age, child sex, maternal age, paternal age, maternal education, paternal education, marital status of parents, household income, and family functioning. Notably, an increasing number of children in a family was significantly associated with a decreased risk of ADHD. Compared to families with three children or above, the odds of ADHD for families with two children and only one child were 1.19 (1.06–1.33) and 1.65 (1.47–1.86), respectively, in the crude model; these odds remained significant in the adjusted model. Similar findings were obtained when the analyses were performed separately for boys and girls.

Compared to those without pets at either age 0–1 or age 1–3 years, children with pets only during age 0–1 year, only during age 1–3 years, and during both age ranges were associated with increased odds of 1.83 (1.49–2.22), 1.71 (1.40–2.08), and 1.82 (1.57–2.10) for ADHD, respectively. The odds remained significant in the multivariate model. Similar findings were observed when analyses were performed separately for boys and girls.

We subsequently examined the interaction between only-child status and pet ownership. Compared to non-only child without pet ownership, pet ownership during either age 0–1 or age 1–3 years was significantly associated with an increased risk of ADHD, regardless of only-child status. Furthermore, only children were associated with increased odds of ADHD irrespective of pet ownership. A significant interaction was noted among only children with pet ownership only during ages 1–3 years (P for interaction = 0.028). When analyses were performed separately for boys and girls, similar findings were observed with significant interaction observed among girls but not boys (Table 3).

Discussion

The current study found that both pet ownership and being an only child were associated with an increased risk of ADHD among Chinese preschool children. However, the detrimental impact of pet ownership appeared to be mitigated among only children when exposure to pets occurred during ages 1–3 years.

The association between being an only child and the risk of ADHD remains inconclusive. The KiGGS study, which included 13,488 children and adolescents, reported no significant associations between the number of siblings and ADHD risk (12). In contrast, a case–control study of 161 pairs of Chinese children with ADHD and matched controls unveiled a positive association between being an only child and ADHD diagnosis (11). Our study also identified an increased likelihood of ADHD among only children. The mechanisms underlying this correlation remain

TABLE 1 Characteristics of participants.

	Overall	ADHD		*p*-value
		No	Yes	
Number	63,282	57,233 (90.4)	6,049 (9.6)	
Child age (years)	4.86 ± 0.85	4.86 ± 0.85	4.82 ± 0.86	0.002
Child sex				<0.001
Girls	29,387 (46.4)	27,269 (47.6)	2,118 (35.0)	
Boys	33,895 (53.6)	29,964 (52.4)	3,931 (65.0)	
Maternal age (years)	33.9 ± 4.4	34.0 ± 4.4	33.1 ± 4.4	<0.001
Paternal age (years)	36.1 ± 5.0	36.2 ± 5.0	35.2 ± 5.0	<0.001
Maternal education				<0.001
Primary or middle school	9,202 (14.5)	8,158 (14.3)	1,044 (17.3)	
High school	12,794 (20.2)	11,556 (20.2)	1,238 (20.5)	
College	39,192 (61.9)	35,580 (62.2)	3,612 (59.7)	
Graduate	2,089 (3.3)	1,937 (3.4)	152 (2.5)	
Paternal education				<0.001
Primary or middle school	8,213 (13.0)	7,276 (12.7)	937 (15.5)	
High school	12,958 (20.5)	11,656 (20.4)	1,302 (21.6)	
College	38,738 (61.3)	35,177 (61.6)	3,561 (58.9)	
Graduate	3,255 (5.2)	3,014 (5.3)	241 (4.0)	
Household income				<0.001
<10,000RMB/month	9,347 (14.8)	8,283 (14.5)	1,064 (17.6)	
10,000–20,000 RMB/month	21,915 (34.6)	19,704 (34.4)	2,211 (36.6)	
20,001–30,000 RMB/month	13,809 (21.8)	12,550 (21.9)	1,259 (20.8)	
>30,000 RMB/month	18,211 (28.8)	16,696 (29.2)	1,515 (25.0)	
Marital status of parents				<0.001
Married	62,666 (99.0)	56,694 (99.1)	5,972 (98.7)	
Unmarried or divorced	616 (1.0)	539 (0.9)	77 (1.3)	
Gestational age (weeks)	39.0 ± 1.6	39.0 ± 1.6	39.0 ± 1.7	0.45
Mode of delivery				
Vaginal	42,286 (66.8)	38,186 (66.7)	4,100 (67.8)	0.099
Cesarean	20,996 (33.2)	19,047 (33.3)	1,949 (32.2)	
F-APGAR score	7.0 [5.0, 10.0]	8.0 [5.0, 10.0]	6.0 [5.0, 8.0]	<0.001
Pet ownership				<0.001
No	60,316 (95.3)	54,726 (95.6)	5,590 (92.4)	
Only during age 0–1 year	744 (1.2)	627 (1.1)	117 (1.9)	
Only during ages 1–3 years	786 (1.2)	669 (1.2)	117 (1.9)	
During both age ranges	1,436 (2.3)	1,211 (2.1)	225 (3.7)	
Number of children (%)				<0.001
1	21,751 (34.4)	19,227 (33.6)	2,524 (41.7)	
2	36,771 (58.1)	33,597 (58.7)	3,174 (52.5)	
3	4,760 (7.5)	4,409 (7.7)	351 (5.8)	

ADHD, attention-deficit/hyperactivity disorder.
F-APGAR, The 5-item Family Adaptation, Partnership, Growth, Affection, Resolve (F-APGAR) scale. A higher score indicates a better family functioning.

unclear. One possible explanation is that only children often receive more attention from family members, which may inadvertently interrupt their activities and affect their ability to concentrate. In addition, only children may lack home-based playmates, potentially hindering their neurodevelopment. Furthermore, heightened parental concern for only children may

10.3389/fpubh.2024.1450216

TABLE 2 Univariate and multivariate logistic regressions on the associations of only-child status and pet ownership with risk of ADHD.

	Crude model		Adjusted model*	
	Odds ratio	*p*-value	Odds ratio	*p*-value
Overall				
Only child (yes vs. no)	1.42 (1.34–1.49)	<0.001	1.30 (1.23–1.38)	<0.001
Number of children				
≥3	1.00 (reference)		1.00 (reference)	
2	1.19 (1.06–1.33)	0.003	1.22 (1.09–1.38)	0.001
1	1.65 (1.47–1.86)	<0.001	1.56 (1.39–1.77)	<0.001
Pet ownership				
No	1.00 (reference)		1.00 (reference)	
Only during age 0–1 year	1.83 (1.49–2.22)	<0.001	1.59 (1.30–1.95)	<0.001
Only during ages 1–3 years	1.71 (1.40–2.08)	<0.001	1.58 (1.28–1.93)	<0.001
During both age ranges	1.82 (1.57–2.10)	<0.001	1.66 (1.42–1.92)	<0.001
Boys				
Only child (yes vs. no)	1.44 (1.34, 1.54)	<0.001	1.33 (1.24, 1.43)	<0.001
Number of children				
≥3	1.00 (reference)		1.00 (reference)	
2	1.24 (1.07–1.44)	0.005	1.25 (1.08–1.46)	0.004
1	1.74 (1.50–2.02)	<0.001	1.63 (1.40–1.91)	<0.001
Pet ownership				
No	1.00 (reference)		1.00 (reference)	
Only during age 0–1 year	1.89 (1.46, 2.42)	<0.001	1.65 (1.26, 2.12)	<0.001
Only during ages 1–3 years	1.75 (1.34, 2.25)	<0.001	1.59 (1.21, 2.05)	<0.001
During both age ranges	1.91 (1.58, 2.29)	<0.001	1.71 (1.41, 2.06)	<0.001
Girls				
Only child (yes vs. no)	1.35 (1.23, 1.47)	<0.001	1.26 (1.15, 1.39)	<0.001
Number of children				
≥3	1.00 (reference)		1.00 (reference)	
2	1.10 (0.92–1.33)	0.287	1.19 (0.99–1.44)	0.066
1	1.47 (1.22–1.78)	<0.001	1.48 (1.22–1.81)	<0.001
Pet ownership				
No	1.00 (reference)		1.00 (reference)	
Only during age 0–1 year	1.78 (1.27, 2.44)	<0.001	1.51 (1.07, 2.08)	0.014
Only during ages 1–3 years	1.76 (1.28, 2.38)	<0.001	1.57 (1.13, 2.12)	0.005
During both age ranges	1.75 (1.37, 2.20)	<0.001	1.57 (1.22, 1.99)	<0.001

*Adjusted for child age, maternal age, paternal age, maternal education, paternal education, marital status, household income, family functioning score, and child sex were additionally adjusted in the overall model.
ADHD, attention-deficit/hyperactivity disorder.

lead to increased reporting of behavioral issues during assessments. It is also worth noting that due to the cross-sectional nature of the current study, we cannot rule out the possibility of reverse causality. For instance, parents of children exhibiting early signs of ADHD may have chosen not to have additional children. Given these complexities, further investigations into the causal relationship between only-child status and ADHD are imperative.

While there is evidence suggesting that pet attachment can positively influence children's neurodevelopment, the relationship between early-life pet exposure and ADHD risk remains ambiguous, with a limited number of studies presenting mixed findings. A prior study involving 4,860 children from 2 German birth cohorts found that pet ownership at any point from birth to age 10 years was linked to higher scores for emotional symptoms and hyperactivity/impulsivity by age 10 years (28). Similarly, the 2003 California Health Interview Survey identified a positive correlation between allowing dogs or cats into the house and ADHD risk (29). However, this association diminished and

TABLE 3 Multivariate logistic regression evaluates the interaction of only-child status and pet ownership at different ages on the risk of ADHD.

	Only child		P for interaction
	No	Yes	
Overall			
Pet ownership			
No	1.00 (reference)	1.32 (1.24–1.40)***	
Only during age 0–1 year	1.59 (1.18–2.11)**	2.00 (1.50–2.64)***	0.827
Only during ages 1–3 years	1.91 (1.48–2.45)***	1.52 (1.07–2.12)*	**0.020**
During both age ranges	1.86 (1.52–2.27)***	1.83 (1.46–2.27)***	0.055
Boys			
Pet ownership			
No	1.0 (reference)	1.35 (1.25–1.45)***	
Only during age 0–1 year	1.72 (1.16–2.46)**	2.03 (1.40–2.87)***	0.622
Only during ages 1–3 years	1.81 (1.28–2.51)**	1.76 (1.12–2.65)*	0.239
During both age ranges	1.97 (1.52–2.52)***	1.89 (1.41–2.50)***	0.080
Girls			
Pet ownership			
No	1.00 (reference)	1.28 (1.16–1.41)***	
Only during age 0–1 year	1.40 (0.84–2.18)	2.01 (1.23–3.11)**	0.726
Only during ages 1–3 years	2.06 (1.39–2.96)***	1.21 (0.64–2.08)	**0.028**
During both age ranges	1.70 (1.20–2.35)**	1.76 (1.22–2.47)**	0.393

Adjusted for child age, maternal age, paternal age, maternal education, paternal education, marital status, household income, and family function score; in the overall model, child sex was additionally adjusted.
ADHD, attention-deficit/hyperactivity disorder. Bold values are significantly findings.

became statistically insignificant after doubly robust adjustments for confounding factors, using models that incorporated both propensity score variables and propensity score weights (29). A U.S. birth cohort study indicated that maternal prenatal dog ownership was positively linked to ADHD in boys but not girls (23). In contrast, another cohort study reported a reduced risk of mental health disorders, including ADHD, in adolescents who had childhood exposure to pet dogs or cats (17). In the present study, pet cat or dog ownership during early childhood was significantly associated with an increased risk of ADHD. Pets may influence children's neurodevelopment in various ways, including potential alterations in the gut microbiome that could affect ADHD risk via the gut–brain axis (30–33). Moreover, pets might introduce environmental toxins (e.g., pesticides) into the home, posing additional ADHD risks (21, 22). Thus, further studies are warranted to elucidate the mechanisms underlying the association between early-life pet exposure and ADHD risk.

Interestingly, the negative effects of pet ownership appeared to be mitigated for only children when pet exposure occurred between the ages of 1 and 3 years. We hypothesize that pet cat or dog companionship may provide emotional comfort, compensating for the absence of siblings. This effect seems particularly evident during the critical developmental window of age 1 to 3 years, a period when children gradually transition from primarily interacting with parents to engaging with peers, acquiring fundamental social skills. Further research is essential to validate our findings and explore the underlying mechanisms.

Limitations

The primary strength of this study is its population-based design, encompassing a substantial sample size of over 60,000 children. However, several limitations must be considered when interpreting the findings. First, the reliance on self-reported data induces potential recall and self-report biases. Second, due to the cross-sectional design, which is susceptible to reverse causality, causal inference is limited. Third, although birth order has been linked to ADHD risk, this study did not collect the birth order data, precluding further investigation into its fluence. In addition, we did not differentiate between pet cats and dogs, despite evidence suggesting they may have distinct impacts on children's neurodevelopment. Furthermore, we did not collect data on ownership of other pets (e.g., birds and fish) which may also influence ADHD risk. Moreover, we lacked detailed information on the duration of children's interactions with their pets, which could mediate the observed effects of pet exposure. Our dataset also lacks information on the family history of ADHD, and given the heritable nature of ADHD, it is conceivable that our findings regarding pet ownership and ADHD could be influenced by unaccounted family history or genetic predisposition. Despite these limitations, this study provides valuable insights into the relationship between pet ownership, only-child status, and ADHD risk. Future longitudinal studies are warranted to address these limitations and establish causal relationships.

Conclusion

This population-based study identifies an association between only-child status, exposure to pet dogs/cats, and ADHD risk among children in China. Families and healthcare providers should be aware of these potential risks. It is essential for parents, particularly those of only children, to adopt appropriate parenting strategies, including providing proper supervision and offering children more companionship to support their emotional and social development. Further research utilizing prospective longitudinal birth cohorts is necessary to elucidate the causal relationships between family-environmental factors and ADHD risk. Such studies may provide a foundation for developing effective interventions aimed at mitigating family-related risk factors and preventing ADHD in children.

Data availability statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the Shenzhen Longhua Maternity and Child Healthcare Hospital, and participants provided informed consent. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

YZ: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing. SQ: Project administration, Resources, Writing – review & editing. VG: Data curation, Funding acquisition, Writing – review & editing. WC: Resources, Supervision, Writing – review & editing. XH: Resources, Writing – review & editing. WY: Conceptualization, Data curation, Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was supported by the Natural Science Foundation of Guangdong Province (No. 2023A1515010425), the Shenzhen Fundamental Research Program (No. JCYJ20220531091200001 and JCYJ20210324122 609025), the Shenzhen Longhua Science and Innovation grant (LHKJCXJCYJ202004) and the National Natural Science Foundation of China (No. 82204069).

Acknowledgments

We sincerely acknowledge the participants for their support of this study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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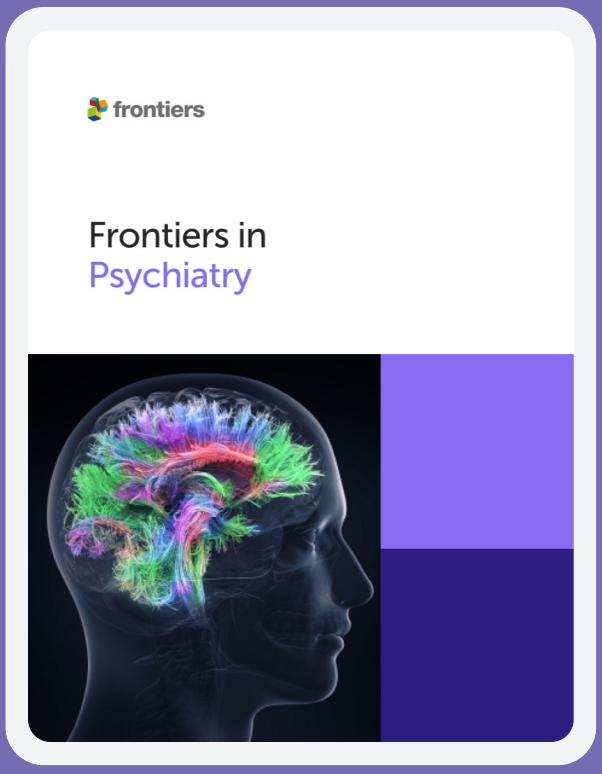

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