

Investigation into the  
behaviour and welfare of  
indoor-housed cats  
*(Felis catus)*

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# ABSTRACT

Numbers of indoor-only domestic cats are rising globally, as is literature suggesting that sickness and undesirable behaviours are more prevalent in indoor-only cats. As cats have had freedom to roam throughout most of their evolutionary timeline, understanding how cats cope in indoor-only environments is important to ensure their welfare and strong cat-owner bonds.

Using surveys, this thesis explored the rationales that owners have for providing indoor-only or indoor-outdoor lifestyles, and cat or owner demographics which might be predictive of a provided lifestyle. Additionally, levels of owner-reported sickness and undesirable behaviours and hair cortisol concentration (HCC) were investigated to ascertain if differences were present between cats with these different lifestyles.

Results provided evidence that problem behaviours exist in a wider variety, and/or higher intensity in indoor-only cats compared to those with unrestricted indoor-outdoor lifestyles, and that HCC levels are higher in indoor-only cats than those with outdoor access. However, this variation cannot be attributed to lifestyle alone, as fundamental differences in levels of enrichment and social intensity were found between the indoor environments of cats across indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor lifestyles. In addition, cat demographic features (e.g. sex, life stage, pedigree status), were found to be significant predictors of lifestyle, and may themselves influence problem behaviours or HCC levels.

Modelling highlighted a range of aspects of a cat's environment that impact problem behaviour scores and HCC, demonstrating that lifestyle is but one aspect that can influence feline behaviour, and potentially wellbeing. Variables showed to significantly impact problem behaviour scores were not consistent between lifestyles, suggesting that owners providing different lifestyles need to take into account different considerations when caring for their cat.

These findings are likely to be useful to cat welfare professionals in the production of advice and guidance for cat owners. These results also highlight the importance of lifestyle classification in future studies, given the significant differences in results observed between cats with managed indoor-outdoor lifestyles in comparison to both indoor-only and unrestricted indoor-outdoor lifestyles.

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# INTRODUCTION

Emerging literature suggests that certain sickness or undesirable behaviours may be more prevalent in indoor-only cats than those with outdoor access (Amat et al., 2009; Barcelos et al., 2018; Finka et al., 2019; Sandøe et al., 2017; Tamimi et al., 2015). Reported differences in behaviour between indoor-only populations and those with outdoor access may be indicative of compromised welfare or inappropriate management practices (Broom, 1986). Alongside welfare concerns, increases in sickness or undesirable behaviours may result in weaker cat-owner bonds (Serpell, 1996), and lead to cats being punished (Grigg and Kogan, 2019) or relinquished (Casey et al., 2009; Jensen et al., 2020). Generally, there is agreement between owners, charities and veterinarians over cat care practices and forms of management that are beneficial for welfare (e.g. neutering, Chu et al., 2009; Murray et al., 2015; Wongsangchan et al., 2019), and those considered to be detrimental (e.g. declawing aka onychectomy, Canadian Veterinary Medical Association, 2017; Ruch-Gallie et al., 2016), although some differences are seen regionally. Lifestyle is, however, a topic of contention; that is, whether cats should be permitted outdoor access in either a restricted or unrestricted capacity or kept as indoor-only and whether this decision leads to potential cat behaviour, health or welfare concerns.

Domestic cats (*Felis catus*) are one of the most globally popular companion animals, with over 100 million owned cats in the United Kingdom (UK) and United States (US) alone (APPA, 2018; PDSA, 2017), thus research into their welfare has the potential to affect millions of individual cats worldwide. In the absence of being able to communicate directly with non-human animal species, different assessment methods are used to infer the welfare of animals at either an individual (Klintip et al., 2022) or population (Kay et al., 2017) level. Welfare can be assessed in the present moment (Kessler and Turner, 1997), over time (Broom and Johnson, 2019), or in the case of some physiological tests (e.g. utilising hormones such as cortisol), historical inferences of welfare can be made (Bechshøft et al., 2011). The most common methods of assessing welfare in animals have typically been based around behaviour, however difficulties with interpretation of behaviour may arise due to differences in behavioural expression between individuals, or due to observer bias' (Serpell, 2019). It is thought that triangulation of multiple welfare measures, including behaviour, physiology and health is likely to be the most robust approach to gaining comprehensive insight into the wellbeing of animals (Duncan, 2005; Hemsworth et al., 2013; Staley et al., 2018). However, to assess the welfare of an animal we must understand the underlying biology, normal behaviour and basic needs of its species (Browning, 2023).

Cats are relatively unique when compared to other domesticated species, as they have not undergone extreme genetic selection for domestic traits (Driscoll et al., 2007, 2009). The domestic cat is a descendant of the wildcat (*Felis silvestris*) (Driscoll et al., 2007). Domestication is thought to have occurred through a natural, commensal process with cats inhabiting human settlements due to the abundance of prey around 12,000 years ago (Cucchi et al, 2020; Nilson et al, 2022). Due to the benefits of pest control cats brought to settlements, their presence appeared to be accepted or even encouraged (Cucchi et al, 2020). Since early domestication, the lack of intense breeding of domestic cats means they are hardly changed in appearance or behaviour, with even the recent breeding of pedigree cats only affecting small portions of genetic material (Nilson et al., 2022). This calls into question how well cats could realistically be adapted to modern lifestyles, particularly confinement to an indoor-only environment within a domestic home. Indeed, many behaviours observed in domestic cats that can be directly linked back to their ancestors may be problematic for owners, for example, being solitary in nature, scratching as a method of remote communication or opportunistic hunting behaviour that may mean even well-fed cats catch prey (Bradshaw, 2018).

It is not yet understood why cats with different lifestyles are reported to have different levels of owner-reported sickness or undesirable behaviours. It is possible that outdoor access represents an opportunity to perform natural behaviours and provides important enrichment that promotes good wellbeing (Bradshaw, 2018). It may be that cats are able to carry out behaviours such as scratching and marking within the outdoor environment without negative repercussions such as the inconvenience and expense of furniture destruction to owners. It may be that certain categories of cats, e.g. those who are not neutered, or those who are pedigree, may have predispositions to displaying problem behaviours and are more frequently kept indoors (Johnson et al., 2017; Tan et al., 2021). Differences in additional environmental factors associated with lifestyle such as levels of enrichment and social environment may play a role (Clancy et al., 2003; Lawson et al., 2019; Tan et al., 2021). We may also see differing definitions of indoor-only or indoor-outdoor lifestyles, depending on the categorisation of interim lifestyles such as catios (i.e. enclosed rooms, often made of wired walls, filled with cat enrichment), leash walking, enclosed garden spaces, or supervised outdoor access (de Souza Machado et al., 2020; Sandøe et al., 2017). Most likely, a combination of all the above factors may contribute to the differing levels of owner-reported sickness or undesirable behaviours in cats of different lifestyle, each of which will be investigated throughout this thesis.

In addition, it is important to identify the underlying reasons owners may choose specific lifestyles for their cats, to understand whether cat welfare forms part of this consideration. Studies thus far have typically been limited to one region and have explored a specific concern e.g. depredation of wildlife, which do not typically place consideration of cat needs or welfare at the forefront of the study. The limited evidence into lifestyle consideration suggests a range of reasons might be considered. Some owners seem to be concerned over dangers such as road traffic accidents, or attacks from large predators or humans who may wish to cause them harm (Tan et al., 2020, 2021). Other owners appear to believe outdoor access provides enrichment that cannot be replicated within the home, thus is beneficial to cat wellbeing. Literature also suggests that concerns may be held over cat depredation on local wildlife populations, although much of this research is limited to Australia, where it is typically perceived to be a negative aspect of owning a cat (Eeden et al., 2021; Mcleod et al., 2015; Toukhsati et al., 2012), or the UK, where the behaviour may be more readily accepted as part of the natural behavioural repertoire of cats (Crowley et al., 2019, 2020). Given global studies and those which recognise owners likely consider a range of factors when deciding on lifestyle are lacking, this is an area that would be pertinent to address. A greater understanding of the rationale behinds owners' decisions will provide insight as to whether owners consider the welfare of their cats and whether they endeavour to meet their cats' needs in the way they best see fit. It may also help us to identify subsets of cats that are more likely to be provided with certain lifestyles, helping animal welfare professionals to tailor guidance for these cats and owners, or identify at-risk populations for inappropriate management practises. Finally, insight into the thought processes of owners may help with human behaviour change campaigns to improve the welfare of cats within our care and the cat-owner bond.

## AIMS AND OBJECTIVES

The overall aim of the thesis is to investigate whether differences in owner-reported behaviour or potential welfare measures differ between cats with indoor-only or indoor-outdoor lifestyles. It will also explore whether other aspects of the environment (e.g. social environment, physical provisions) significantly differ between, or are associated with, different lifestyles, or whether different types of cats are likely to be provided with different lifestyles and whether these factors might impact any differences seen in behaviour or welfare measures. The rationales of owners will also be investigated, to understand if the welfare of their cat is a consideration of owners in making these decisions, and what the main reasons for their choice of lifestyle are. To aid in achieving all the above, a sound understanding of the literature will be sought through systematic reviews prior to the start of the original research.

The thesis will be presented as a series of chapters each with its own introduction, aims and objectives, methods, results, discussion and reference list. With the above aims in mind, the specific aims of each chapter are as follows:

CHAPTER ONE: A systematic review of social and environmental factors and their implications for indoor cat welfare

- Elucidate what is currently known about the impact that the environment has on the behaviour and welfare of cats indoor-housed cats and identify knowledge gaps within the literature

CHAPTER TWO: Are multi-cat homes more stressful? A critical review of the evidence associated with cat group size and wellbeing

- Critically appraise the existing literature to provide a summary of the relationships between cat group size and wellbeing in the domestic home, as measured by physiological and/or behavioural outcomes
- Highlight risk factors associated with potential compromises to wellbeing
- Highlight limitations within the current evidence base and provide recommendations for further research

CHAPTER THREE: Indoors or Outdoors? An International Exploration of Owner Demographics and Decision Making Associated with Lifestyle of Pet Cats

- Identify if different owner features or cat demographics are associated with greater odds of cats having an indoor-only or indoor-outdoor lifestyle
- Elucidate the extent to which factors identified from the literature influence owners when making lifestyle decisions for their cat, and what proportion of owners consider the different lifestyle options available
- Establish major narrative themes around owner decision making

CHAPTER FOUR: Associations between cat lifestyle, behaviour, owner management and environment

- Identify if owner-reported levels of problem behaviours vary with indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor lifestyles
- Investigate whether significant differences exist between the management and environment of cats with indoor-only, managed indoor-outdoor and unrestricted

indoor-outdoor lifestyles are evident, with regards to social aspects and physical provisions

- Explore whether different variables contribute towards the levels of owner-reported problem behaviours across cats with indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor lifestyles

CHAPTER FIVE: An exploration of factors affecting expression of cortisol in the hair of domestic cats (*Felis catus*)

- Assess whether differing levels of mean hair cortisol concentrations are found between different subpopulations of owned domestic cats
- Investigate whether there are any correlations between HCC and problem behaviour scores
- Explore whether environmental or demographic variables that predict problem behaviour score also predict HCC levels

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# CHAPTER ONE: A SYSTEMATIC REVIEW OF SOCIAL AND ENVIRONMENTAL FACTORS AND THEIR IMPLICATIONS FOR INDOOR CAT WELFARE

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MF - Consensus opinion on the inclusion of papers; supervision and guidance

## 1. INTRODUCTION

In 2017 there were an estimated 10.3 million owned cats in the United Kingdom (UK) (PDSA, 2017) and 94.2 million owned cats in the United States of America (USA) (APPA, 2018). Housing practices for domestic cats (*Felis catus*) vary. Within Europe, cats are typically afforded an indoor/outdoor lifestyle whilst cats in the USA are more routinely kept indoors. Reasons such as fear of road traffic accidents, theft or attack by humans or animals play a role in the decision to keep cats as indoor-only (McLeod et al., 2015; Toukhsati et al., 2012). Increasingly, urbanisation is reducing owner access to outdoor spaces and so the number of indoor cats is expected to increase. Additionally, concern over the impact of cat depredation on wildlife is growing, especially in places where cats represent an introduced predator. Partial or complete indoor housing is seen as one mechanism to reduce the impact of cats on wildlife (Linklater et al., 2019). Suburbs in Australia have imposed a 'cat curfew', restricting cats to indoors during designated times, whilst other suburbs prohibit cats from being let outside entirely (Australian Capital Territory Government, 2018). In New Zealand, Marlborough District Council requires a multiple cat licence to be sought by those wishing to own more than four cats, to limit the cat population in areas where birds may be at risk and prevent public nuisance (Marlborough District Council, n.d.), although it is unclear why a threshold of four was chosen.

Typically, outdoor access has been accepted as beneficial for both the physical and mental wellbeing of cats (International Cat Care, n.d.<sup>a</sup>), and little is currently known about how well cats adapt to an indoor lifestyle. Compared to species such as dogs, cats have a relatively unique evolutionary history, with less intensive selection for domesticated traits (Driscoll et al., 2007). Consequently, cats exhibit behavioural characteristics and needs very closely aligned to their ancestors, including the drive to hunt, preference for a solitary lifestyle, territorial behaviour, crepuscular activity and a desire to bury faeces and urine (Bradshaw, 2018). As with all sentient species, poor welfare and problem behaviours may arise if behavioural needs are not met (Broom, 1986). In cats, common problem behaviours include inappropriate elimination, spraying, excessive vocalisation, scratching furniture and aggression towards owners, strangers or other animals (Heidenberger, 1997). These problems are reported to be more prolific in indoor cats compared to indoor/outdoor cats, and this finding appears to be consistent across cats across a variety of countries (e.g. Spain (Amat et al., 2009), Denmark (Sandøe et al., 2017); France, (Schubnel & Arpaillange, 2008)). Some behaviours are found in almost twice the number of indoor cats compared to outdoor cats. For example, both Sandøe et al. (2017) and Schubnel and Arpaillange (2008) report significantly higher levels of house soiling or inappropriate elimination in indoor cats compared to outdoor cats, at the levels of 18.2% and 34% of indoor

cats vs 9.8% and 16% of outdoor cats respectively. There may be an increase in cat-owner conflict if the behaviours are prolonged or particularly undesirable, potentially leading to abandonment or relinquishment. In the UK, it has been estimated that around 38% of cats returned to shelters were brought in due to behavioural problems, predominantly aggression towards people or conspecifics (Casey et al., 2009).

Understanding which environmental aspects of a home may provide a positive experience for a cat is important to ensure good welfare. Cat welfare charities recommend provisions of food and water bowls, litter trays and scratching posts to meet basic needs. Additional recommended enrichment often alludes to hiding spots, vertical vantage spots and toys which can emulate hunting (Herron & Buffington, 2010; International Cat Care, n.d.<sup>b</sup>). Yet environments are complex and multivariate, both physically and socially, thus the provision of structures and objects may only play a small role in providing for positive welfare. How cats perceive their daily interactions with people, conspecifics or heterospecifics such as dogs, and how this alters their behaviour, could be as important as the provision of physical items. Cats living in groups have been shown to occupy smaller ranges within a home (Bernstein & Strack, 1996), which may limit access to space and resources provided. Welfare may also be impacted, as when owners of both a cat and dog were surveyed, 20.5% of owners reported they perceived their cat to be uncomfortable in their dog's presence on a daily to weekly basis (Thomson et al., 2018). Understanding the impact of each variable and their complex interactions is necessary to ascertain the extent to which indoor and outdoor environments can result in positive welfare for cats. Not only can an appropriate environment enhance their quality of life, but it can also impact upon the human caregiver. In dogs, it has been seen that reducing problem behaviours strengthens animal-owner bonds through increasing owner satisfaction with their animal (Herwijnen et al., 2018). In turn, strong animal-owner bonds provide benefits in terms of companionship and decreases the chances of animal relinquishment (Patronek et al., 1996).

Homes are not the only human mediated indoor environment in which cats reside. Annually, shelters in the UK and USA, see an estimated 150,000 (Clark et al., 2012; Stavisky et al., 2012) and 3.2 million (ASPCA, n.d.) cats respectively. Cats are also routinely kept in research laboratories for studies of pet products and medical testing. In these spaces, cats are typically kept in smaller, confined spaces with reduced complexity, they may also have less human interaction and have a socially unstable environment. Individuals may be subject to changing caregivers and periods of intense interactions such as veterinary examinations or surgeries, before paradoxically facing sedentary lifestyles with little variation or stimulation. Many studies aim to provide knowledge to enhance welfare in these environments through correct care

provision and appropriate enrichment. For example, the exploration of clicker training as a form of social enrichment and method of alleviating stress (Kogan et al., 2017), investigation into whether cats infected with Feline Immunodeficiency Virus (FIV) have different enrichment preferences to non-infected cats (Kennedy et al., 2018) or quantifying any effect of pheromones on stress levels (Chadwin et al., 2017). Although these environments diverge substantially from the typical home of a companion cat, they may be able to provide valuable insight as to how permanent indoor housing may affect cats.

This study uses a systematic review to collate and assess current scientific knowledge concerning the impact that the environment has on indoor-housed cats. By doing so it aims to elucidate what is currently known about those effects on the behaviour and welfare of cats. In addition, areas which require further exploration will be identified.

## 2. METHODOLOGY

### 2.1. SCOPE OF THE LITERATURE

For the purposes of this review, environment was taken to mean both the physical and social environments. For the physical environment (objective one) papers were deemed to be relevant if the welfare or behaviour of cats was being studied in any indoor capacity i.e. a home, laboratory, cattery or rescue centre. Research with an outdoor area was included if that area was enclosed, as were studies where cats were confined for the full duration of the research. Papers which utilised indoor/outdoor cats as well as indoor cats were included providing specific results pertaining to indoor-only cats were discussed.

Regarding the social environment (objective two), research was included if it related to the interaction between cats and any form of caregiver (e.g. owner, shelter staff or researcher), conspecifics, or other species with whom they shared their indoor dwelling. Literature based on subjective report (i.e. those pertaining to studies addressing the human-animal bond and pet-owner attachment) were not included in the analysis, although they were retained for discussion.

### 2.2. SEARCHES

The online databases Scopus (<https://www.scopus.com/>), Web of Science (WoS) (<https://www.webofknowledge.com>) and Google Scholar (GS) (<https://scholar.google.co.uk/>) were used to conduct the searches. These databases were chosen due to the quantity and availability of relevant journals and the breadth of literature covered. Boolean search phrases (see below) were used to retrieve the relevant literature. These searches were optimised

through repeat iterations of the Boolean phrases until the literature returned was maximised. Some phrases which appeared relevant to the search objective (e.g. cat-cat, cat-dog) were not included in the final search term due to the increased number of irrelevant papers that were returned when included (e.g. papers discussing veterinary treatment). It was anticipated that papers discussing cat-cat or cat-dog interactions would be returned by the search phrase for objective one, so the omission from the search term was deemed acceptable. For thoroughness, the references of papers included within the review were checked for relevance and potential inclusion if identified, however no missing papers were found.

*Boolean phrase for objective one:* (cat OR feli\*) AND (indoor\* OR shelter\* OR pen\* OR adopt\* OR rescue\* OR house\* OR home\*) AND (welfare OR behav\* OR enrich\* OR stress\*)

*Boolean phrase for objective two:* (cat-owner OR owner-cat OR staff-cat OR cat-staff OR human-cat OR cat-human OR cat-caregiver OR caregiver-cat OR carer-cat OR cat-carer) AND (interact\* OR behav\* OR social\* OR relat\*)

Literature was exported into Mendeley for sorting. Due to the number of short phrases used within the search terms, substantial numbers of papers were returned. Returns were sorted by relevance. Using Scopus, the first 2000 citations were taken using an in-built feature that allowed a maximum of 2000 citations to be downloaded at once. From Web of Science, all citations were taken as this value was less than 2000. From Google Scholar, due to the vast quantity of items returned and the anticipated duplication across the other two search engines, the first 350 citations were taken and the subsequent 200 citations (i.e. 351-550) checked for relevance. More details of the search items returned can be found in the results section, 3.2.

### 2.3. LITERATURE FILTERING

Literature retained was filtered using a step-wise process for both objectives. Only primary data were retained for analysis, whilst advisory material on enrichment and educational material on feline behaviour were retained for discussion only. Additionally, any papers in which an indoor environment was considered a minor or contributing variable, without being a substantial focus, were not included and likewise retained for discussion. Papers included were restricted to those published in English.

The process of refining the literature was as follows. Firstly, duplicates of citations retrieved by multiple databases were merged within the Mendeley desktop program. Secondly, titles were used to determine if the work was related to the domestic cat; if not it was removed. Titles were used again to remove citations not obviously relevant to indoor or social environments. Next,

abstracts were assessed. Finally, the full-text was read to ensure the record was relevant to the research objectives.

## 2.4. DATA EXTRACTION

Once the relevant material was identified, pertinent data from each paper were extracted and inputted into Microsoft Excel. Data extracted can be found in table 1, in addition to the citation. For a summary of each paper’s major findings, see appendix A1. Papers were also categorised into groups based on the relevant research objective, with some papers being relevant to both objectives. More details on the categorisation of papers for each research objective can be found below.

### 2.4.1. ENVIRONMENT

Three major research environments: house, laboratory and shelter/cattery, were identified. House environments were the homes of owners in which the cat permanently resided. Laboratory studies were those conducted within a dedicated research facility. For the latter, cats were typically born in the facility and received daily care from a research team, although some studies (n=5) used cats taken from shelters or homes to a research facility for the duration of the experiment and subsequently returned. Shelters and catteries were grouped for analysis due to environmental similarities where cats were confined to pens or rooms. Feeding, cleaning and grooming were routinely provided by various carers and the environment could contain sights, sounds and smells of unknown conspecifics.

**Table 1, Types of data extracted from papers:** Specific data extracted from each document classed as relevant to the systematic review

<b>Data categories</b>	<b>Variables</b>
Study characteristics	Year of publication, study origin, place of publication
Methodological characteristics	N number of participants, controls used, variables studied, measurement type, study length, limitations
Environmental characteristics	Social or physical environment, experimental setting, single or group housing
Cat characteristics	Age of cats, neuter status, sex

## 3. RESULTS

The results returned for the search terms in each of the databases are detailed in figure 1. In total, 61 papers were retained for analysis; 33 papers arising from search objective one and 28



papers from search objective two. Of the 61 papers, the foci were: social environment n=7, physical environment n=11 and both social and physical environments n=43. A summary of each of the papers can be found in the appendix, A1.

### 3.1. DATE OF PUBLICATION

Of the data retained, n=16 papers were published between 1991-2000, n=11 between 2001-2010, and n=34 between 2011-2018.

### 3.2. RESEARCH ENVIRONMENTS

Of the studies that utilised one research environment, the most frequent was a shelter/cattery (n=23), then the home environment (n=18) and then laboratory (n=16). Four studies compared results from multiple environments, with n=2 comparing shelters and houses, n=1 a cattery and house and n=1 a shelter and cattery.

### 3.3. SOCIAL INTERACTIONS

Of the 50 papers that considered behaviour and welfare based on social interactions, n=24 explored cat-cat and n=15 cat-human and n=2 cat-dog. Nine papers considered multiple social relationships between humans, cats and/or dogs. The three papers covering cat, dog and human interaction used survey methodology to consider the overall home environment, which included cat-owner interaction and, briefly, the presence of other cats or dogs (Adamelli et al., 2005; Heidenberger, 1997; Shyan-Norwalt, 2005).

### 3.4. MEASURES OF BEHAVIOUR AND WELFARE

Methodologies employed to assess behaviour and welfare predominantly fell into distinct groups, the majority of which are discussed below. More than one method was utilised by n=31 papers.

#### 3.4.1. OBSERVATIONS

Behavioural observations were used in n=47 studies. Observations were collected through video recordings (n=18) and/or the presence of an observer (n=30). Observations were sampled continuously (n=29) and/or via scan sampling (n=22). The data recorded from observations were most commonly explored using ethograms (n=32) to record frequency and/or duration of behaviours. Data were also used to measure cat-stress-score (CSS) (n=13) (discussed further below).

### 3.4.2. SURVEY

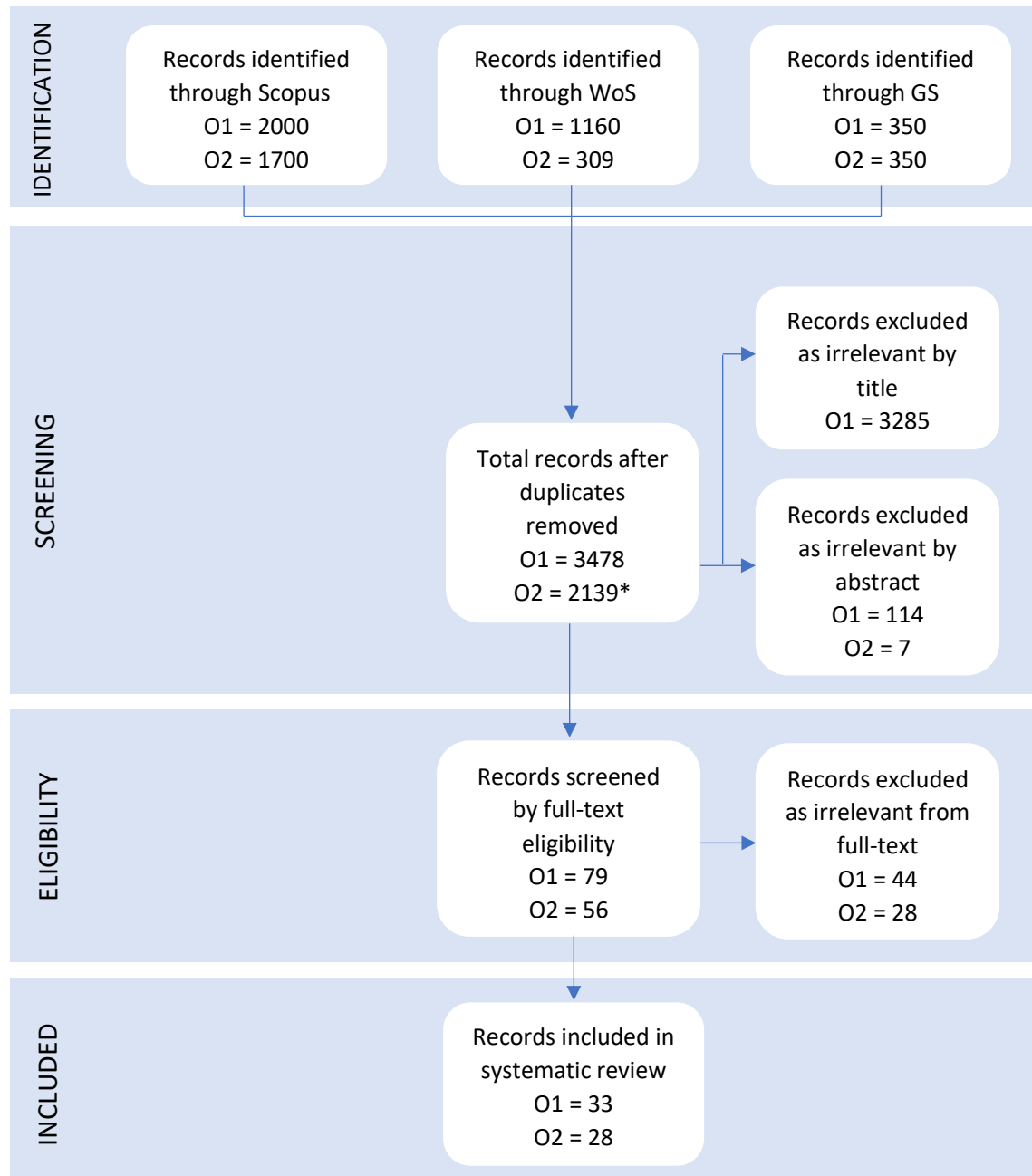
Different forms of surveys or questionnaires were used for n=13 papers. These were often directed at owners and assessed physical environmental composites (Strickler & Shull, 2014) or social interaction (Rochlitz et al., 1998<sup>b</sup>). Personality was explored by Ramos et al. (2013) who asked owners to assess their cat's personality.

### 3.4.3. PHYSIOLOGICAL MEASURES

These were assessed in n=8 papers. One paper used two physiological measures and so nine methodologies were used in total. Measurements such as cortisol levels, immune function and creatinine:cortisol levels were taken from blood (n=2), urine (n=4) and faeces (n=3).

**Figure 1, Flow chart of paper selection:** Flow chart depicting the number of citations obtained from each search engine, Scopus, Web of Science (WoS) and Google Scholar (GS), for objective one: physical environment (O1) and objective two: social environment (O2), and the records removed at each step based on the eligibility criteria. The flow chart has been adapted from Moher et al. (2009).

\* When duplicate records from objective two were removed these included duplicates of records found using the objective one search terms.



### 3.5. MAJOR FINDINGS

Many studies focussed on similar areas. A summary of the major findings across multiple studies can be found below, whilst a brief summary of each study can be found in the appendix, A1. The major findings are discussed further in 3.1.6, the limitations section, and table 3.

**Table 2, Summary of major findings within reviewed papers:** A summary of the major findings compiled from similar studies included in this review.

<p><b>Box/hiding enrichment</b></p>	<p>Provision of hiding enrichment was primarily associated with reduced CSS compared to a control group without hiding enrichment (Kry &amp; Casey, 2007; Vinke et al., 2014), although Moore and Bain (2013) found no significant effect of hiding or toy enrichment on CSS.</p> <p>A change in behaviour was seen compared to control cats without enrichment, including increased active and inactive behaviours (de Oliveira et al., 2015) and an increase in relaxed behaviours and human approach behaviours (Kry &amp; Casey, 2007).</p> <p>Increased utilisation by cats experiencing more stress (Ottway &amp; Hawkins, 2003; Rehnberg et al., 2015; Stella et al., 2014, 2017).</p> <p>Preference of hiding enrichment over other forms of enrichment (Ellis et al., 2017b).</p>
<p><b>Environmental acclimation</b></p>	<p>CSS was found to change following entry into a new environment, such as a shelter or cattery. Longer length of stay correlated with decreased cat stress scores within the first week (Broadley et al., 2014; Kessler &amp; Turner, 1997, 1999a; Kry &amp; Casey, 2007; McCobb et al., 2005; Moore &amp; Bain, 2013; Rehnberg et al., 2015; Vinke et al., 2014) and second week (Kessler &amp; Turner, 1997; Kry &amp; Casey, 2007; McCobb et al., 2005; Vinke et al., 2014), although one study found that at two weeks in an unenriched environment, CSS started to increase compared to after one week (Kry &amp; Casey, 2007).</p> <p>After significantly declining from day 1, CSS was found to stabilise between 3-5 days depending on conditions such as single or group housing, prior socialisation or enrichment (Broadley et al., 2014; Kessler &amp; Turner, 1997,</p>

	<p>1999a; Kry &amp; Casey, 2007; McCobb et al., 2005; Moore &amp; Bain, 2013; Vinke et al., 2014)</p> <p>CSS decreased faster in cats with hiding enrichment than those without (Kry &amp; Casey, 2007; Vinke et al., 2014), faster in cats housed in groups compared to singly (Kessler &amp; Turner, 1997) and faster in those with more human interaction (Rehnberg et al., 2015).</p> <p>Cats not socialised with people (as assessed by the authors using a human-approach-test and a socialisation questionnaire provided to 29 owners) had a higher overall CSS compared to those socialised with people in both group and single housing and cats not socialised with cats (as assessed by the authors using a cat-approach-test and a socialisation questionnaire provided to owners) had a higher overall CSS when housed in groups compared to when housed singly (Kessler &amp; Turner, 1999a).</p>
<p><b>Stress in single vs group housing</b></p>	<p>Results on stress in single and group housing were inconclusive. For cats socialised with other cats several studies found no difference in stress indicators between single and group housing. Kessler and Turner (1997, 1999a) found no difference in CSS between cats in single or group housing. Single and group housing was found to have no impact on faecal glucocorticoid metabolites (GCM) across two studies (Ramos et al., 2012, 2013). Lichtsteiner and Turner (2008) found single or group housing had no influence on urinary cortisol level.</p> <p>Other studies however did find a difference. Two studies found group housing was less stressful than single housing. Gourkow and Fraser (2006) found CSS was generally higher in single, unenriched cages compared to unenriched group or enriched group/single housing. Uetake et al. (2013) found urine cortisol-to-creatinine ratios were generally higher in single housed cats than group housed. Ottway and Hawkins (2003), however, found CSS was higher in group housing than single housing.</p> <p>Cats not socialised with other cats displayed more stress in group housing than single housing (Kessler &amp; Turner, 1999a).</p>

### 3.6. LIMITATIONS

As detailed in table 3, numerous limitations were identified, with the major two being small sample sizes and inconsistent methodologies across repetition of study objectives.

Limitations were decided through consideration of good experimental design, such as the use of large sample sizes and methodological consistency. As detailed by Taborsky (2010), sample sizes for behavioural studies do not appear to be standardised, with chosen sample sizes often arising from the number of subject available, limited resources, time constraints or convenience, rather than being optimised. Whilst optimal sample sizes vary depending on the analysis being completed, where  $n < 25$ , studies were highlighted as having a potential issue with small samples sizes.  $N=1$  studies were highlighted separately, due to the more preliminary status of the findings.

Other limitations were experimental design details which may have inadvertently impacted results by introducing variation and reducing comparability between individuals or groups in the study. For example, Broadley et al. (2013) utilised cats who had entered the shelter within the previous 7 days. Results of behavioural observations can be expected to differ between a cat residing in a new environment, in this case a shelter, for 1 day when compared to 7 days. Whilst time on site before observation was considered as a variable, as each individual is likely to acclimatise at a different rate from a different starting level of stress, this is still a limitation of the experiment.

Studies with sample biases are limited as the results may not be applicable to all cats. For example, Strickler and Shull (2014) distributed surveys to attendees of veterinary hospitals to assess toys, activities and problem behaviours, and Feuerstein and Terkel (2008) recruited cat owners from notices placed around a university. Convenience sampling may inadvertently select owners who are more conscientious or provide better care for their cats, as they are willing to attend a veterinary centre or more keen to participate in research. Whilst demographic, representative samples are not required, it must be considered that not all cats are living in such environments.

Studies conducted over a short duration, categorised here as 4 days or shorter, are detailed in table 3. The results of these studies may be impacted by acclimation of cats to a new environment, which as seen in the results of the cat-stress-score studies can take up to 5 days, dependant on factors such as enrichment. Results of studies assessing the impact of enrichment within an environment may also be impacted by a novelty effect of items if tested over a short

duration, and longer studies may help to ascertain whether items have the capacity to alter behaviour or improve welfare in the long-term.

Whilst some limitations listed in the table are not necessarily true limitations, they can be defined as problems which are limiting this field of work e.g. repetition of box studies.

#### *SMALL SAMPLE SIZES*

These were identified in n=32 papers, with an additional n=9 papers being effectively N=1 studies. Studies were classed as having a small sample size if they had n<25 participants in any given experiment. These studies may suffer from reduced confidence intervals in statistical testing, especially if smaller subgroups are being compared. Whilst there is still value in the results of these studies, the results may not be applicable to wider cat populations, and so they must be interpreted with caution. The smallest samples were n=7 (Rochlitz et al., 1998a), n=13 (n=9 and n=4 in the experimental and comparison groups respectively; Soennichsen and Chamove, 2002) and n=16 (n=8 and n=8 in the experimental and comparison groups; Carlstead et al., 1993) Some papers started with larger samples, however, comparing results between experimental groups substantially diminished sample sizes. For example, Ramos et al. (2012) used n=30 subjects, n=14 housed singly and n=16 housed in groups, reducing independent samples to n=14 individuals and n=6 groups. Desforges et al. (2016) used n=48 individual cats, but only n=4 groups. Bradshaw and Hall (1999), who were studying pairs, used n=50 individuals, therefore n=25 pairs, and compared results between related and unrelated pairs, taking the group sizes down to n=14 and n=11 respectively. Studies with the smallest samples were frequently those studying large group behaviour. Many of these studies (n=9) were found to be n=1 studies (as detailed in table 3), as only one group population with multiple members was utilised per study.

### 3.7. INCONSISTENT METHODOLOGY

Similar methodologies were used across numerous studies, namely CSS, ethograms and human-approach-tests (HATs), however, the methods were often inconsistent or modified reducing the comparability across studies.

#### *CAT-STRESS-SCORE*

Cat-stress-score (CSS) as devised by Kessler and Turner (1997), is utilised in N=13 papers. CSS is often used to monitor stress over time, either in response to a new environment or to compare stress between treatment groups and a control group, when provided with items such as a hiding box (Vinke et al., 2014) or pheromones (Chadwin et al., 2017). The original methodology

for measuring CSS averaged two CSS recorded within 15 minutes of each other. Generally, most studies used the mean of at least two scores per recording, although Broadley et al. (2014) and Chadwin et al. (2017) utilised only one. Vinke et al. (2014) used four CSS measurements taken within 20 minutes to form an average. McCobb et al. (2005) recorded two scores, but after an interval of ‘at least 15 minutes’, suggesting the interval times may have varied.

#### *ETHOGRAM*

Behavioural assessment using an ethogram was the most frequently employed methodology (n=30), however, there was little standardisation between studies. Some studies used comprehensive ethograms to record a wide scope of behaviours (Podberscek et al., 1991) whilst others had a strict focus, such as Snowdon et al. (2015) who were recording behavioural responses to music. Several papers studying cat-cat interactions categorised behaviours as affiliative or agonistic, yet again, these behaviours were not standardised (Barry & Crowell-Davis, 1999; Dantas-Divers et al., 2011). Typically, a single observer coded the ethogram, either whilst observing in real-time or from a video after the event, although not all papers detailed how many observers completed the ethogram (Feuerstein & Terkel, 2008). Training on the use of ethograms was not detailed. Where multiple observers were used and interobserver reliability identified, high levels of agreement were reported. Kogan et al. (2017) detailed a correlation of 0.990 and Snowdon et al. (2015) a concordance of 94.5%.

**Table 3, Limitations of papers within the review:** Limitations of the relevant articles included in the systematic review.

Limitation	References
<b>N &lt; 25 (some or all parts of experiment)</b>	Barry and Crowell-Davis, 1999; Bradshaw and Hall, 1999; Carlstead et al., 1993; Desforges et al., 2016; Ellis et al., 2015; Ellis et al., 2017a; Eriksson et al., 2017; Fazio et al., 2017; Gouveia et al., 2011; Kennedy et al., 2018; Kessler and Turner, 1997, 1999b; Kry and Casey, 2007; Lichtsteiner and Turner, 2008; Loberg and Lundmark, 2016; McGlone et al., 2018; de Monte and le Pape, 1997; Moore and Bain, 2013; Naik et al., 2018; Ottway and Hawkins, 2003; Ramos et al., 2012; Ramos et al., 2013; Rehnberg et al., 2015; Rochlitz et al., 1998a, 1998b; Soennichsen and Chamove, 2002; Stella et al, 2014, 2017; Uetake et al., 2013; Vinke et al., 2014; Vitale Shreve et al., 2017; Zhang et al., 2018



<b>N=1 study</b>	Bernstein and Strack, 1996; Damasceno and Genaro, 2014; Dantas-Divers et al., 2011; de Oliveira et al., 2015; Parker et al., 2017; Podberscek et al., 1991; van den Bos, 1998a, 1998b; van den Bos and de Cock Buning, 1994	
<b>Modified cat stress score</b>	Broadley et al., 2014; Chadwin et al., 2017; Gourkow and Fraser, 2006; Kessler and Turner, 1997, 1999a, 1999b; Kry and Casey, 2007; Loberg and Lundmark, 2016; McCobb et al., 2005; Moore and Bain, 2013; Ottway and Hawkins, 2003; Rehnberg et al., 2015; Vinke et al., 2014	
<b>Inconsistent ethogram</b>	Barry and Crowell-Davis, 1999; van den Bos, 1998a, 1998b; van den Bos and de Cock Buning, 1994; Bradshaw and Hall, 1999; Dantas-Divers et al., 2011; Desforges et al., 2016; Ellis and Wells, 2007; Ellis et al., 2015; Eriksson et al., 2017; Feuerstein and Terkel, 2008; Gouveia et al., 2011; Loberg and Lundmark, 2016; Mertens, 1991; McGlone et al., 2018; de Monte and le Pape, 1997; Moore and Bain, 2013; de Oliveira et al., 2015; Ottway and Hawkins, 2003; Podberscek et al., 1991; Rehnberg et al., 2015; Rochlitz et al., 1998a; Snowdon et al., 2015; Soennichsen and Chamove, 2002; Stella et al., 2014, 2017; Uetake et al., 2013; Vinke et al., 2014; Vitale Shreve et al., 2017; Wedl et al., 2011	
<b>Short study (&lt;4 days)</b>	Damasceno and Genaro, 2014; de Oliveira et al., 2015; Rehnberg et al., 2015; Stella et al., 2014, 2017	
<b>Study exploring pre-established effects</b>	<b>Box/hiding enrichment</b>	Ellis et al., 2017b; Kry and Casey, 2007; Moore and Bain, 2013; de Oliveira et al., 2015; Ottway and Hawkins, 2003; Rehnberg et al., 2015; Stella et al., 2014; Stella et al., 2017; Vinke et al., 2014
	<b>CSS over time</b>	Broadley et al., 2014; Gourkow and Fraser, 2006; Kessler and Turner, 1997; Kessler and Turner, 1999a; Kry and Casey, 2007; McCobb et al., 2005; Moore and Bain, 2013; Rehnberg et al., 2015; Vinke et al., 2014
	<b>Stress in group vs single housing</b>	Kessler and Turner, 1997, 1999a; Gourkow and Fraser, 2006; Lichtsteiner and Turner, 2008; Ottway and Hawkins, 2003; Ramos et al., 2012; Ramos et al., 2013; Uetake et al., 2013
<b>Varying acclimation time pre-trial</b>	Broadley et al., 2014; Kessler and Turner, 1999a; Kry and Casey, 2007; Ottway and Hawkins, 2003; Vinke et al., 2014; Vitale Shreve et al., 2017	

<b>between individuals</b>	
<b>Observer present</b>	Barry and Crowell-Davis, 1999; Bradshaw and Hall, 1999; Gourkow and Fraser, 2006; Mertens, 1991; Rehnberg et al., 2015; van den Bos, 1998a, 1998b; Wedl et al., 2011
<b>Sample bias</b>	Ellis et al., 2015; Feuerstein and Terkel, 2008; Heidenberger, 1997; Kessler and Turner, 1997, 1999a, 1999b; Ramos et al., 2012; Ramos et al., 2013; Strickler and Shull, 2014; Shyan-Norwalt, 2005; Thomson et al., 2018
<b>Low interobserver reliability</b>	Broadley, et al., 2014; Kessler and Turner, 1997, 1999a, 1999b

#### 4. DISCUSSION

Research into the behaviour and welfare of indoor cats is a growing area of interest, with 61 papers identified since 1991, and more papers published in the last decade than the two previous decades combined. Despite this, the current breadth of knowledge remains small when considering the complexity of environmental variables that may affect the behaviour and welfare of individual cats.

##### 4.1. MAJOR FINDINGS

###### *CAT-CAT LITERATURE*

Cat-cat interaction was frequently studied in group housing. For cats who have not chosen to cohabit, as those within feral colonies may do out of necessity, understanding group interactions with conspecifics is important to minimise conflict and maximise welfare.

When providing enrichment, it is important that enough enrichment is provided to ensure all cats can access it. Large enrichment items such as cat trees or benches were shown to be utilised by multiple cats at once (Loberg & Lundmark, 2016). Yet with smaller items, it was found that within groups certain individuals more frequently commandeered the use of enrichment items (Bernstein & Strack, 1996; Damasceno & Genaro, 2014; Loberg & Lundmark, 2016). Once additional resources were added, these were utilised by other individuals (Bernstein & Strack, 1996; Damasceno & Genaro, 2014). This indicates it was likely that group social structure and dynamics, as opposed to lack of interest, modified enrichment use. Typically, feline behaviour experts recommend providing one of each resource type (e.g. litter tray, water bowl) per cat, plus one spare, to reduce conflict and improve welfare (PDSA, 2013), yet no literature within

this review was found to investigate this recommendation. As of now, it appears that this claim is untested, although it may still be beneficial.

Cats appear to have preferred areas within their environment, which they frequent more often or in which they spend significantly more time (Barry & Crowell-David, 1999; Bernstein & Strack, 1996). Although cats have been shown to time-share spaces and resources (Bernstein & Strack, 1996), ensuring that cohabiting cats can access a variety of resource-rich areas may promote good welfare by reducing conflict over home ranges. This advice is often provided by feline behavioural experts, although whether resource dispersion is beneficial in reducing conflict or improving welfare is untested as of yet. In general, an increase in space, or decrease in population density, may be beneficial to welfare. For example, Loberg and Lundmark (2016) found increased space increased the time spent performing solitary play behaviour, a commonly accepted indicator of positive welfare.

Aggression was frequently studied. Ethograms included subtle displays of aggression such as piloerection, ear turning or flattening and staring, alongside more overt displays such as pouncing, mounting, swatting or biting (Barry & Crowell-Davis, 1999; Dantos-Divers et al., 2011; Lichtsteiner & Turner, 2008), although not all ethograms were standardised. Observations conducted across laboratory, shelter and home environments and of varying group sizes with differing sex ratios, generally all found low rates of conflict (van den Bos et al., 1994, 1998b; Bernstein & Strack, 1996; Dantos-Divers, 2011). Pairs of cats that have lived together longer in homes appear to have reduced rates of aggression than those cohabiting for shorter periods (Barry & Crowell-Davis, 1999). This may be due to the dynamics of the social dyads being more stable, as hierarchies and home ranges are well established. Cohabiting cats with high levels of aggression may also face relinquishment, removing them from the population of animals being studied.

Whilst low conflict may be considered more neutral than a positive marker of a relationship, several indicators of affiliative relationships were established. Related cats kept in a shelter environment were found to have more affiliative behaviours than unrelated pairs (Bradshaw & Hall, 1999), whilst sex had no impact on affiliation in related or unrelated pairs. Barry and Crowell-Davis (1999) additionally found that sex had no impact on affiliative behaviours or aggression in pairs living together, although it did appear to influence proximity, with male/male pairs spending more time near one another.

### *CAT-OWNER LITERATURE*

A major feature in the environment of cats in homes is the owners or family with whom the cat resides. As the primary caregiver, an owner's actions or personality can impact on the welfare of their cat (Finka et al., 2019). In the indoor environment especially, cats only have access to items that the owners have provided, intentionally or otherwise. This may be problematic as solely indoor cats do not have the opportunity to seek out provisions or items to meet their needs. Adamelli et al. (2005) found owner gender, education and number of friends were major factors influencing the care provided for cats, and thus the cat's quality of life, with cats with female owners spending more time with their owner, owners with low education brushing their cat less and owners with fewer friends feeding their cat correctly.

In addition to physical provisions and resources, there is a social relationship between the cat and the owner. This dyad has been suggested as more important than cat-cat dyads, or the physical environment in impacting welfare (Adamelli et al., 2005; Lichtsteiner & Turner, 2008; Ramos et al., 2012). The cat-owner relationship seems in many instances to be beneficial to the cat although this is not necessarily always the case (Finka et al., 2019). Heidenberger (1997) found that owners who spent several hours throughout the day with their cats reported fewer problem behaviours in their cat, although it is not clear from the study what this is in comparison to. A study on owner-cat separation showed that after spending 4 hours apart from one another, cats purred more at reunion than they did after 30 minutes (Eriksson et al., 2017). When a 3-month separation period was studied for cats in quarantine, ~40% of owners reported their cat to be more attached to them 2-weeks and 3-months post-release than before quarantine, and 3-months after release they reported their cats spent more time with them than before quarantine (Rochlitz et al., 1998b). The results from Eriksson et al. (2017) and Rochlitz et al. (1998b) may suggest the cat-owner bond is important and there is a want to re-establish a connection after a period of separation.

### *ENRICHMENT*

There is robust evidence that hiding enrichment is utilised by cats when given the opportunity and that it positively impacts welfare. Within a novel environment, such as entry into a shelter or cattery, hiding provisions reduce behavioural and physiological stress markers. Cats displaying evidence of stress utilise hiding opportunities more (Ottway & Hawkins, 2003; Rehnberg et al., 2015; Stella et al., 2014, 2017). Cats with hiding enrichment displayed more rapidly declining CSS than those without (Kry & Casey, 2007; Vinke et al., 2014). Cats with hiding enrichment were

observed to spend more time inactive compared to control groups (Kry & Casey, 2007; de Oliveira et al., 2015), indicating they were more comfortable within their own environment.

Hiding motivation was explored by comparing comfortable resting spots to hiding areas by Vinke et al. (2014). When provided, hiding boxes were the most utilised area, leading the authors to conclude that hiding boxes are not just comfortable, but have a 'main concealing function'. Further evidence that motivation is concealment over comfort can be seen within other studies, where cats lacking hiding enrichment exhibited behaviours that researchers interpreted as trying to hide. These behaviours were described as 'resting behind the litter pan' by Carlstead et al. (1993), 'crouching behind their beds' by Kry and Casey (2007) and spending time 'behind their litter box' by Vinke et al. (2014).

## 4.2. LIMITATIONS

### *INCONSISTENT METHODOLOGIES*

Despite many studies utilising similar methodologies, inconsistencies diminish the ability to compare results between papers thus making a statistical meta-analysis of previous data not possible. Cat Stress Score is one of the most utilised methods within the reviewed papers (n=13). It has benefits in that it is quick, can be performed by anyone with little training, and is non-invasive, meaning it is a valuable tool for researchers and those interacting with cats daily. However, its application did not always conform to the methodology devised by Kessler and Turner (1997).

Despite being easy to use, it is uncertain how frequently CSS was being applied in a correct or valid way. During its development Kessler and Turner (1997) detailed that interobserver reliability is high, at 0.9, when utilised by two trained observers, yet in those with less training this reliability drops to 0.75. The papers in this review scarcely detail the training undergone in CSS prior to use, so it is not certain that observers across different studies are consistent with their scoring. Additionally, most papers utilised one observer which may reduce reliability when compared with average scores from multiple observers. Loberg and Lundmark (2016) did utilise multiple observers, however scores were not recorded simultaneously and averaged, meaning multiple observers may reduce consistency between scores. Whilst it was detailed that observers practiced together to ensure interobserver reliability, no quantified score was provided. Broadley et al. (2014) also used multiple observers, yet only reported an interobserver correlation of 0.64 between the researcher and an experienced observer, further highlighting issues with consistency across the application of CSS.

Where CSS was utilised, the behaviours used to score stress levels between 1 and 7 were adhered to by all papers, although Vinke et al. (2014) omitted vocalisation. Variation in the methodology of measuring CSS was found within repeated measurements. Repetition improves reliability, however some studies omitted repetition and averages (Broadley et al., 2014; Chadwin et al., 2017), whilst others extended the original average of two measurements to an average of four measurements (Vinke et al., 2014), and there was often variation in the time between measurements, from 5 minutes per observation, to 'at least' 15 minutes between observations (McCobb et al., 2005).

The CSS measurements also varied relative to the time of day they were recorded. Broadley et al. (2014) measured CSS between 12:00h - 15:00h, as they suggest scores may vary throughout the day as cortisol levels do. McCobb et al. (2005) found CSS was significantly higher in the morning, although Loberg et al. (2016) did not find this was the case. Whilst variations in McCobb et al. (2005) may be due to environmental factors, controlling for potential variables where possible, such as time of day, could increase reliability when comparing studies.

Overall, despite the inconsistent application of CSS, papers with similar foci, for example CSS over time, do broadly agree with one another. Variations in findings may be attributable to methodological differences or other confounding variables.

#### *SMALL SAMPLE SIZES*

Several papers derived findings from N=1 studies. Typically, N=1 studies were group studies investigating social behaviour. It is perhaps due to the scale of these studies, including the length and quantity of data to be processed, as well as access to subjects, that only one group was utilised. Whilst it is possible to compare results between similar N=1 studies, differences such as the number of cats in the colony, the size of the environment, the enrichment present or the presence of humans, means conclusions are reduced to generalised statements, and more specific nuance amongst results remain under-investigated. These studies still have value in that they may highlight important variables worthy of further investigation, and provide interesting case studies for the dynamics of specific groups, however the lack of independent measures within the experimental designs reduces the ability to extrapolate findings to the wider population.

#### *REPETITIVE STUDIES*

Whilst it is important that replication establishes findings are valid, 15% (n=9/61) of all studies had a large, intentional focus on the impact of a hiding box on behaviour and welfare. This can be considered excessive. This is especially so when all studies concur that boxes are well utilised

by cats and beneficial to their behaviour and welfare. Additional studies included hiding boxes as a provision of enrichment whilst investigating other variables. Whilst hiding behaviour may have been included on ethograms, this was not a substantial focus and thus these studies were not included in the count. Given the many variables within a cat's environment, there remains substantial opportunity to explore other environmental variables that may influence behaviour and improve welfare.

#### *APPLICATION TO HOME ENVIRONMENT*

Whilst most indoor cats globally are found within homes, most of the studies were completed in a shelter, cattery or laboratory. Advice and guidance documents providing recommendations for ensuring good welfare in the home are therefore likely to use results obtained in environments other than the home. It must be considered that these results may not be transferrable between environments. Indeed, inconsistencies in results between similar studies may be down to different environments and consequently, guidelines for enrichment found in the non-peer reviewed literature pertaining to the welfare of indoor cats, remain to be scientifically validated.

Hiding enrichment, for example, was primarily investigated in shelters, catteries and laboratories. Studies often focused on adaptation to a new, relatively barren, environment, which may be less relevant to cats living in homes where complexity is substantially greater. Bernstein and Strack (1996) provided boxes within a group home environment to explore social structure through observation. Here, boxes were found to be utilised for several hours a day when introduced, but a novelty effect meant that after 5 days usage diminished. With the introduction of a new box the interest once again increased. Comparing studies within shelters with those in the home environment suggests that boxes may be utilised differently by cats in a stable environment versus those in a novel environment. Hiding enrichment could still be beneficial in the home for indoor cats, but may be superseded by incidental and permanent hiding spaces (e.g. behind or underneath other structures).

Feeding enrichment items, such as puzzle feeders, are additionally promoted as beneficial to increase activity and alleviate boredom, therefore improving welfare (Ellis et al., 2013; Stella et al., 2017), yet these claims are not wholly demonstrated in the literature. Whilst Dantas-Divers et al. (2011) and Damanesco et al. (2014) both found that feeding enrichment was interacted with by many individuals within a group when provided in a shelter, Naik et al. (2018) found that, compared to standard bowl feeding, exclusively using puzzle feeders did not increase activity levels in cats in the home. No welfare measurements of cats provided with enrichment

were taken and so, whilst puzzle feeders were interacted with, it cannot be said whether this significantly improved welfare. These examples demonstrate the need for large-scale, in-home studies into behaviour and welfare to ensure that research is applicable to, and beneficial to, a large a population of cats as possible.

### 4.3. KNOWLEDGE GAPS

#### *LONG-TERM STUDIES*

Many studies investigated the time taken for cats to adapt to a new environment and ways to mitigate the stress faced during this adjustment period. Overall, the consensus was that a 3-5 day period was required for CSS to fall to an acceptable level (table 2). Whilst this is important in scenarios where cats are being rehomed or boarded, it does not help us to understand long-term stress within complex environments. Chronic stress and the concomitant changes in cortisol levels may have a more detrimental effect on welfare than acute stress. Systemic cortisol elevation over a long period can cause metabolic changes and decreased immune function, increasing susceptibility to disease (Heimbürge, 2019). Whilst it is important to mitigate stress in all scenarios, home-life typically comprises the largest number of cats, and the majority of those cats' lifetimes. Therefore, increasing welfare in the home, and our understanding thereof, will have the greatest impact on cat welfare overall. Within this review, the only long-term studies focused on cats spending six months in quarantine, thus it is reasonable to state these results will not contribute towards understanding welfare in the home.

#### *COMPLEX ENVIRONMENTS*

As is typical in experimental design, many studies focus on a single variable, for example, litter tray preference (Grigg et al., 2012), reaction to auditory stimulation (Snowdon et al., 2015) or effect of feeding enrichment (Damasceno et al., 2014). Studies with one variable help to ensure any differences between groups most likely result from the factor under investigation. Whilst exploring individual variables within the environment is important, it is also important to understand the complex interactions between the numerous variables in a given environment and how they can impact behaviour and welfare as a whole. The presence of one item in a study may be beneficial to behaviour or welfare in an otherwise stark environment, yet in practice, the benefits of the item may be inconsequential in a complex environment. Preference tests are a good way of determining the importance of objects to cats. Yet as preference tests tend to be short-term studies, there could be a potential novelty effect which diminishes over time and thus removes the long-term benefits of the object. Heidenberger (1997) and Shyan-Norwalt (2005) utilised surveys to gain an insight into the different aspects of the home environments of



respondents' cats. These surveys are useful in evaluating what recommended enrichment is being provided for cats, the interaction cats have with their environment and the social interaction cats experience. If these aspects could be linked to indicators of welfare, it may be possible to determine which factors have the greatest impact in the home. Strickler and Shull (2014) used owner surveys to link play behaviour and enrichment to aggressive or problematic elimination behaviours in the home. They identified several variables associated with increased problem behaviours. For example, owners who played with their cats for five minutes at a time reported fewer problem behaviours than owners who played for one minute at a time. Extending surveys to include a stronger emphasis on problem behaviours could substantially develop our understanding of the environmental factors that have the biggest influence over cat behaviour and welfare in the home.

#### *CAT-CHILD RELATIONSHIPS*

Several studies allude to the possibility that the impact of humans in the social environment has a greater effect on welfare and behaviour than that of conspecifics (Adamelli et al., 2005; Lichtsteiner & Turner, 2008; Ramos et al., 2012). Despite this, more studies considered cat-cat relationships (n=33) than cat-human relationships (n=24). Additionally, the studies in this review exploring cat-human relationships focus predominantly on adult relationships, and cat-child interactions remain largely unexplored. The cat-child relationship is briefly explored by Heidenberger (1997), who reported cats in households with children displayed less problem or anxious behaviours, and Mertens (1991) who found cat-child dyads made more approach behaviours than cat-juvenile or cat-adult dyads. These findings were small components within larger studies and so it is difficult to conclusively identify how the presence of children may impact upon cats. It could be reasoned that children may be intimidating to cats of certain dispositions due to the potential for unpredictable movement and sound, loud noises or heavy handedness. A study by Hart et al. (2018), suggested cat-child relationships are perceived as less affectionate and more problematic than cat-adult relationships. Single cat relationships with children were found to be less affiliative than those in multi-cat households. This may be due to having more attention directed towards them if they are the only cat. For indoor cats especially, inability to escape the attention of children, or any human resident, may be a chronic stressor reducing overall welfare.

#### *CAT-DOG RELATIONSHIPS*

Little literature exists relative to cats and dogs who cohabit (n=5). A recent survey (Murray et al., 2009) estimates that 7% of UK households contain both a cat and a dog, suggesting this dynamic affects many cats. Feuerstein and Terkel (2008) and Thomson et al. (2018) both

investigated the cat-dog relationship specifically, whilst two others briefly incorporated the cat-dog dyad into larger cat lifestyle surveys (Heidenberger, 1997; Shyan-Norwalt, 2005). Dogs were typically a minor variable within the research e.g. the presence of a dog was all that was considered, rather than more detailed exploration such as prevalence of positive or negative interactions, the time spent together, length of time cohabiting, methods of introduction, meaning little can be understood concerning the relationship between the species and its impact on behaviour and welfare. Both studies of cat-dog relationships relied heavily on owner-reported relationships and quantification of owner perception of interactions. Owner perceptions can be largely subjective, and there may be limited behavioural understanding of the interactions or differences in the interaction being reported, leading to incorrect interpretation and report. Whilst Feuerstein and Terkel (2008) used video recording to quantify frequency of interactions, this single study was limited to 45 subjects preventing overarching conclusions from being drawn around the intricacies of cat and dog relationships. It does however provide a good grounding for future investigation.

#### *VALIDITY OF CSS USED IN SOCIAL SITUATIONS*

CSS was widely used in social groups in addition to single cats. CSS was developed by Kessler and Turner (1997) as an adaption of the Cat-Assessment-Score laid out by McCune (1994). Kessler and Turner (1997) detail how the revised ethogram was applied to single, pair and group-housed cats during its development and is thus applicable to cats in any housing situation. Yet the ethogram does not contain any measures pertaining to social behaviour, such as allogrooming, sniffing or vocalisations. This may reduce its validity in social situations. As indicated by the authors during the development of CSS, it would be beneficial to validate the behaviours against physiological parameters. This may help to confirm whether behavioural stress indicators are the same for cats housed singly or in groups. However, Rehnberg et al. (2015) investigated CSS alongside glucocorticoid metabolites and found no correlation between the two. It might be that there is a latency period between the outward expression of CSS and the physiological response as expressed in faecal samples, and so further studies are warranted. For now, when utilising CSS measurements of cats housed in groups, it is worth considering that the results may be less valid than for those housed singly.

## 5. CONCLUSION AND RECOMMENDATIONS

The relationship between cats and complex home environments is of increasing importance due to the rising numbers of cats being kept indoors. The dearth of studies in the home indicates the requirement for more research. As many studies concerning hiding enrichment, cat-cat social behaviour and relationships, and group and single housing have been conducted in shelters,

catteries and laboratories inference is difficult. Substantially more cats live in homes meaning that improving our understanding of the impact of the home environment is imperative to improving companion cat welfare. As access to the home environment presents methodological challenges it remains largely unexplored. This area may be filled most readily by feline behavioural consultants who already have regular access to assessing behaviour in this environment.

To optimise the impact of research, focus should be placed on the gaps in knowledge identified herein. This should include investigations into cat behaviour and physiology with respect to the cat-child and cat-dog relationship. The cat-owner relationship is additionally worthy of further exploration, given the importance this variable has been to studies so far.

It is additionally important to ensure future results are as meaningful as possible. Standardisation of methodologies such as ethograms and measuring CSS could be beneficial. Whilst results have been relatively consistent thus far with varying methodologies, standardisation would improve the reliability of comparing results between studies. It is also important for studies to ensure sample sizes are sufficient to provide reliable results. Thus far, sample sizes have often been small, even  $n=1$ , reducing the ability to apply results to scenarios other than the case being studied.

Complexity is another area which is lacking. Whilst single-variable studies are useful, it is important to understand how variables fit into the bigger picture. Once factors are considered within the environment as a whole, the effect of the variable may be diminished by other environmental factors, and of the majority of indoor cats, environments are not well controlled, but rather dynamic and constantly evolving.

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# CHAPTER TWO: ARE MULTI-CAT HOMES MORE STRESSFUL? A CRITICAL REVIEW OF THE EVIDENCE ASSOCIATED WITH CAT GROUP SIZE AND WELLBEING

The following chapter has been published, as presented, in the following location:

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Author contributions were as follows:

RFW - Methodology; literature search, refinement and selection; data extraction; results; discussion; writing; redrafting.

LF - Methodology; consensus opinion on the inclusion of papers; data extraction; results; discussion; writing; redrafting.

Note: This paper built upon previous work by L.R. Finka (Finka et al., 2014) and so the decision was taken to publish with Dr. Finka as the lead author to help increase the visibility of the work to those interested.

## 1. INTRODUCTION

As one of the most globally popular companion animals, the domestic cat experiences a diverse range of lifestyles and types of human management. Across these lifestyles, cats may encounter a range of environments and associated restrictions, from free-living outdoors, to confinement within rehoming centres, or living within the domestic home. In each case, space and resource availability typically vary (e.g. see Calhoun & Haspel, 1989; Heidenberger, 1997; McCobb et al., 2005), as do the nature and degree of social interactions with both humans and conspecifics (Bradshaw & Hall, 1999; Mertens, 1991; Natoli & De Vito, 1991). At a species level, the domestic cat is capable of exhibiting an impressive level of social flexibility, enabling individuals to live in social groups with conspecifics and/or other species (including humans), or alternatively live independent of social contact. At an individual level, some cats may transition across lifestyles and associated degrees of sociality within a generation, or even a single lifetime (Bradshaw et al., 1999). For example, a singly housed pet cat may choose to stray from their domestic home and associate with other free-living cats in a colony. Equally, a solitary living cat born from feral or free-living parents may end up residing with humans and other cats within a domestic home. This may sometimes occur voluntarily on the cats' part, although is often the result of the cat being extracted from their original environment by humans. The capacity of individuals to adapt to these different lifestyles may depend on a complex interaction of factors. These include endogenous factors such as age, sex, neuter status and personality, and exogenous factors such as current resource availability and distribution, cat sex ratio, group size and familiarity and relatedness amongst conspecifics (see Curtis et al., 2003; Karsh & Turner, 1988; Liberg et al., 2000; Macdonald et al., 2000; McCune, 1995).

In free-living contexts, domestic cats demonstrate diversity in both their spatial and social organisation, occupying a range of lifestyles from being primarily solitary (Genovesi et al., 1995) to living in groups (Liberg et al., 2000). When group living does occur, these are predominantly matrilineal, temporally stable, and resource-dependent, forming around a clumped food source (Macdonald et al., 2000). For group members, familiarity and relatedness appear important mediators of affiliative interactions (Curtis et al., 2003). Non-group members, especially when unrelated and female, are rarely tolerated and generally avoided (Liberg et al., 2000). Much of the cats' communicative repertoire is dedicated to the use of olfactory cues via semiochemicals, in combination with visual markers such as scratching (Feldman, 1994; Pageat & Gaultier, 2003). These behaviours facilitate remote forms of communication that avoid the need for close proximity to conspecifics or, importantly, non-group members. Indeed, distance-increasing

strategies may be the preferred methods of avoiding inter-cat conflict in this species (Leyhausen & Tonkin, 1979).

Where cats are housed in confined spaces such as laboratories, rehoming centres or domestic homes, group living is usually determined and directly managed by humans. Group composition may therefore vary greatly compared to those formed by cats in free-living populations. For example, unfamiliar, unrelated cats of both sexes and from a range of backgrounds may be introduced and housed together as adults (Kessler & Turner, 1999; Levine et al., 2005). Within these contexts, limitations of resource abundance and distribution relative to the requirements of group members may occur, with effective avoidance and distance increasing strategies to reduce conflict less available. These vastly different circumstances to those of self-selecting populations may present challenges to group members that could be detrimental to their wellbeing.

In the rehoming centre context, studies assessing the stress levels of cats relative to their social housing type have produced mixed results. Some evidence suggests communal housing is associated with higher levels of stress (Ottway & Hawkins, 2003), whilst other studies indicate higher stress in singly housed cats (Gourkow & Fraser, 2006) or no difference between housing types (Kessler & Turner, 1997). However, a critical appraisal of the body of evidence identified several human, cat and environment factors that may be as, if not more, important than single or group housing alone (Finka et al., 2014). These factors included handling and husbandry styles (Gourkow & Fraser, 2006), environmental disruption (Uetake et al., 2013) socialisation history of cats towards humans and conspecifics (Kessler & Turner, 1999) and social stability of cat groups (Kessler & Turner, 1997). Whilst the authors pointed out that methodological limitations made direct comparison between housing types across studies difficult, these findings highlight the complex, multifactorial nature of social and environmental variables and their impacts on cat wellbeing.

In the domestic home, cats are frequently housed together (Murray et al., 2010). Here, variations in the nature of conspecific relationships are evident, but with agonistic encounters seemingly commonplace (Elzerman et al., 2019; Pryor et al., 2001). Additionally, with a limited repertoire for proximal forms of conflict diffusion in confined environments (see Bradshaw, 2016), cats may utilise remote communicative strategies such as scratching and urine marking (Feldman, 1994) inside the home (Barcelos et al., 2018). These behaviours can be problematic for owners to manage successfully and may result in cat relinquishment (Casey et al., 2009; Salman et al., 2000; Scarlett et al., 1999). Multi-cat households may therefore be associated with

negative welfare outcomes for cats; something routinely highlighted in the literature where advice for their management is discussed (Clark, 2016; DePorter et al., 2019; Heath, 2010; Pachel, 2014; Ramos, 2019; Ramos & Reche-junior, 2016; Rodan & Health, 2015).

Interestingly, the impact of single versus multi-cat living or variations in cat group size in the domestic home, and the role of potential mediating factors, does not appear to have been the primary research goal of many studies (see Foreman-Worsley & Farnworth, 2019). Some useful information may be gleaned from published literature, however relevant findings are typically a small component of the overall study (e.g. Adamelli et al., 2005; Heidenberger, 1997; Pryor et al., 2001), and thus not investigated or reported in detail. Given the global prevalence of multi-cat households (ranging from 41.7% of cat households surveyed in the UK (Murray et al., 2010), to 73.6% in Italy (Mariti et al., 2017)) and the seemingly common occurrence of inter-cat conflict in multi-cat homes (Elzerman et al., 2019; Pryor et al., 2001), it is important to have an appropriate scientific evidence base to facilitate a better understanding of potential wellbeing impacts upon individuals, and how these might be mitigated.

In this review, we therefore aimed to critically appraise the existing body of peer-reviewed literature, to provide a cohesive summary of current evidence on the relationships between cat group size (from single ( $n=1$ ) to multi-cat groups ( $n\geq 2$ )) and cat wellbeing in the domestic home, as measured by physiological and/or behavioural outcomes. Our secondary aims were to highlight specific risk factors associated with potential compromises to wellbeing in these contexts (such as various social and environmental parameters), as well as to highlight limitations within the current evidence base and provide recommendations for further research.

## 2. METHODS

### 2.1. FOCUSED CLINICAL QUESTION

In [cats kept in the home environment] does [cat group size] result in [differences in physiological and/or behavioural wellbeing]?

### 2.2. LITERATURE SEARCH

A Boolean phrase was devised to search for relevant literature, based on our focused clinical question. As the authors were familiar with the research area, the phrase was optimised iteratively to ensure it returned all anticipated literature. The final phrase used was as follows:

(cat\* OR feli\*) AND (multi\* OR singl\* OR group\* OR commun\* OR discrete OR social\* OR environment\* OR hous\* OR hom\*) AND (welfare OR behav\* OR enrich\* OR stress\* OR physi\* OR problem\* OR risk\* OR conflict\*)



Searches were completed in Scopus, Web of Science and Google Scholar in June 2020. These electronic databases were chosen due to the large quantity of literature they contained and their wide scope of source material. Searches were carried out on titles, keywords and abstracts and no date restrictions were imposed on returned literature.

From each database, the first 200 returns were exported into Mendeley. The next 200 titles were checked and exported if a potentially relevant paper was found. This continued until a consecutive batch of 200 papers with no apparent relevance to the review were returned. In total, 2200 papers were exported across the three databases - 1000 from Scopus, 800 from Web of Science, and 400 from Google Scholar. These papers were collated in Mendeley and the 'merge duplicates' function used to ensure each paper was unique. After removing duplicates, 1334 individual papers remained for filtering.

#### *FILTERING*

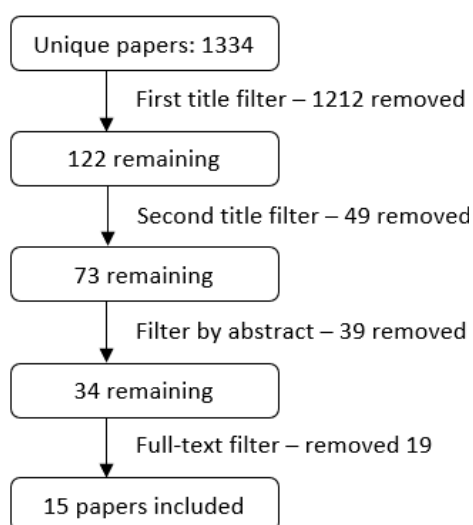
For inclusion, both authors independently ensured the literature met the following criteria:

- A focus on domestic cats kept in the domestic home, including original observed or experimental data that was peer-reviewed, with the full text available in English.
- Comparisons across both single ( $n=1$ ) and multi-cat ( $n\geq 2$ ) housing conditions and/or comparison of different multi-cat group sizes, within a single study, with outcome measures that were either behavioural, physiological, or both, and were deemed as relevant indicators of (or at least likely to be highly associated with) wellbeing.
- Indicators of wellbeing included any outcome measures that provided potential information on the positive or negative welfare state of individuals, in line with modern concepts of animal welfare and overall quality of life (Kendal & Ley, 2006; Mellor & Beausoliel, 2015). Papers where links between cat group size and (physical health) outcome measures were limited to the transmission of infectious disease were not included. However, we otherwise took a broad approach to the inclusion of wellbeing-linked measures (e.g. human and cat-directed aggression, house soiling and urinary problems (i.e. straining to urinate, vocalising when urinating, blood in urine, urethral obstruction), obesity, urinary and faecal cortisol concentrations, anxiety and owner accounts of 'problematic' or 'concerning' behaviours).

Filtering was completed in a stepwise manner. Initially, titles were checked and papers not discussing domestic cats were removed. A second title review was completed to assess the potential relevance of the paper to the focused clinical question. Next, papers were filtered by abstract, and finally, a full-text review was completed. This process is illustrated in figure 2.

Filtering by title and abstract was completed by RFW. Full-text reviews of all remaining literature were completed by both authors, with a consensus reached on all papers selected for inclusion, based on their relevance to our focused clinical question. For thoroughness, the references of all eligible papers were checked for their potential relevance for inclusion to ensure no papers had been missed. These checks yielded no additional papers.

**Figure 2, Stepwise filtering of literature:** Stepwise filtering process of unique papers obtained through Scopus, Web of Science and Google Scholar database searches. Full-text filtering was completed by both authors who reached a consensus on the papers eligible for inclusion.



### 2.3. DATA EXTRACTION AND CRITICAL EVALUATION

Papers were divided at random between authors for information extraction in order to complete the work efficiently; this was undertaken using a standardised set of pre-agreed parameters that were considered relevant to the topic of the review and the focused clinical question. Pre-agreed parameters covered aspects such as cat and owner demographics, details of the cat's living environment, social, environmental and wellbeing-linked variables measured, study intervention or comparisons and key findings relevant to the main study objectives (i.e. significant relationships between cat wellbeing outcomes, multi-cat group size and other exogenous and endogenous factors). Extracted data were initially entered into a master table, which both authors then independently reviewed and jointly edited to ensure consensus of study interpretations and presentation of information. Once consensus of interpretations was confirmed, both authors jointly discussed the main limitations evident across the reviewed literature and categorised these into key themes. Limitations were identified on the basis of their impact on the strength of presented evidence in support of our focused clinical question.

Data relevant to key findings were then exported into the tables presented within the results section, with the remaining information placed in the appendix, A2.

### 3. RESULTS

From a total of 1334 unique studies initially identified, 15 were retained based on their relevance. These were taken forward for critical appraisal and data extraction (see tables 4-6 and A3).

#### 3.1. GENERAL OVERVIEW OF STUDIES

Nine studies were cross-sectional surveys (the most common study design) and incorporated analytical and/or descriptive elements (Adamelli et al., 2005; Barcelos et al., 2018; Elzerman et al., 2019; Grigg & Kogan, 2019; Heidenberger, 1997; Kendall & Ley, 2006; Lawson et al., 2019; Levine, 2005; Pryor et al., 2001). Of the six remaining studies, four were observational analytic cohorts (comprising one exclusively survey-based study (Roberts et al., 2020) and three including biological sampling (Lichtsteiner & Turner, 2008; Ramos et al., 2012, 2013). The final two studies were retrospective and based on information gathered during behavioural consultations (one analytic (Amat et al., 2009) and one purely descriptive (Olm & Houpt, 1988)). No standardised study design classification was used to categorise studies as classification systems are often top-level, instead, the grouping was intended to convey the specific methodology used within the literature.

The following parameters varied both within and across study types;

##### *POPULATION SIZES OF BOTH HUMANS AND CATS*

Survey-only studies ranged from 74 humans reporting on 74 cats (Pryor et al., 2001) to 12,010 owners reporting on 23,920 cats (Lawson et al., 2019). Studies including biological sampling ranged from 12 owners sampling 18 cats (Lichtsteiner & Turner, 2008) to 60 owners sampling 120 cats (Ramos et al., 2013).

##### *GEOGRAPHIC REGIONS SAMPLED*

Only one study included international respondents (Barcelos et al., 2018), these were predominantly from Brazil, UK, Portugal, USA and Australia. The remaining studies sampled within a single country, including the UK, Germany, Switzerland, Italy, Spain, Brazil, the USA and Australia. In several cases, sampling was limited to a specific region (e.g. local vet clinics and regional newspapers (Pryor et al., 2001; Ramos et al., 2013) or a single facility or organisation (e.g. a university (Adamelli et al., 2005; Olm & Houpt, 1988), shelter (Levine et al., 2005) or veterinary clinic (Amat et al., 2009)).

*DEMOGRAPHIC INFORMATION COLLECTED, SOCIAL AND ENVIRONMENTAL PARAMETERS  
MEASURED AND GENERAL STYLES OF INFORMATION REPORTING*

Details reported for both humans and cats varied but were generally brief. Human demographic information included the total numbers of individuals participating and their country of origin, with the exception of Adamelli et al. (2005), Elzerman et al. (2019), Grigg & Kogan (2019), Heidenberger (1997) and Kendall & Ley (2006) where additional information such as the proportion of male/female respondents, their age ranges, average number of cats owned and ownership period were also mentioned. In general, slightly more demographic information was provided for cats including their ages, sex, breed, neuter and health status, whether declawed and source of origin. Again, these details varied across studies and in some cases were minimal (Kendall & Ley, 2006; Lawson et al., 2019; Pryor et al., 2001).

Collected measures relevant to the cat's social and physical environment also varied in nature and detail across studies, from a broad range of measures (Grigg & Kogan, 2019; Lawson et al., 2019) to only a few (Adamelli et al., 2005; Amat et al., 2009; Olm & Houpt, 1988; Pryor et al., 2001; Ramos et al., 2012). Measures included the absolute number of cats and humans per household and also per m<sup>2</sup> within a household, neighbourhood cat density (known number of cats from other households in immediate area), amount of human handling and time left alone each day, owner social behaviour and perceived quality of life, owner attachment to cat, cat 'dominance rankings', presence of other animals in home, basic resource provisions such as food, scratching posts, litter trays (in some cases their total amount per household and per cat, their location, cleanliness and substrate types), type of outdoor access, size of household, amount of indoor space available to the cat, opportunities for climbing and play.

*OUTCOME MEASURES ASSOCIATED WITH WELLBEING*

Outcome measures varied and mostly focused on negative (rather than positive) aspects of wellbeing. 'Problem behaviour' was one of the most commonly assessed variables and was mainly used as an umbrella term to represent behaviours considered problematic or concerning to owners (e.g. anxiety, scratching furniture, aggression (conspecific and human directed), house soiling, undesirable sexual behaviour, liveliness, destructiveness, vocalisation, escaping, roaming and hunting), although examples of reported 'problem behaviours' varied slightly across studies (e.g. Amat et al., 2009; Grigg & Kogan, 2019; Heidenberger, 1997; Olh & Houpt, 1988). Several papers focused on specific behaviours that might otherwise have been included under the generic term of 'problem behaviour'. These behaviours included house soiling and urinary issues (e.g. straining to urinate, vocalising when urinating, blood in urine, urethral obstruction (Barcelos et al., 2018; Lawson et al., 2019; Olm & Houpt, 1988; Pryor et al., 2001),

the owner's perception of the cat's general behaviour (e.g. level of anxiety, timidity, nervousness and shyness (Barcelos et al., 2018; Elzerman et al., 2019; Heidenberger, 1997; Kendall & Ley, 2006)), as well as human directed aggression (Amat et al., 2009; Kendall & Ley, 2006; Roberts et al., 2020) and inter-cat conflict (Amat et al., 2009; Kendall & Ley, 2006; Levine et al., 2005; Roberts et al., 2020). In some cases, physical or physiological indicators such as cat obesity (Heidenberger, 1997), faecal glucocorticoid metabolites (Ramos et al., 2012, 2013) and urinary cortisol to creatinine ratios (Lichtsteiner & Turner, 2008) were sampled, although most studies relied solely on owner reports of cat health and wellbeing based on behavioural outputs. These ranged from structured, quantitative observations (e.g. number and location of urine marks in the home over a two-week period (Pryor et al., 2001), frequency of cat fights per week (Levine et al., 2005) and number of cat bites within the last year (Roberts et al., 2020), to general impressions of the cat such as their demeanour (Barcelos et al., 2018; Elzerman et al., 2019; Ramos et al., 2013). In total, only three studies included biological measures relevant to wellbeing (e.g. faecal glucocorticoid metabolites urinary cortisol to creatinine ratios (Lichtsteiner & Turner, 2008; Ramos et al., 2012, 2013)).

#### *ANALYTICAL APPROACHES*

A range of analytical approaches and subsequent tests were applied to a suite of demographic and cat management variables. Variables were tested relative to few (e.g. Grigg & Kogan, 2019; Heidenberger, 1997), and greater (e.g. Roberts et al., 2020) amounts of wellbeing-related outcomes. For example, in Heidenberger (1997) cat/owner/housing variables were assessed individually for their relationship with the presence of cat problem behaviour (i.e. yes/no) and anxiety (present/absent). In Roberts et al. (2020), cat/owner/housing variables were tested for their relationship with cat obesity, periuria, cat bites to owner and other negative cat-owner interactions, as well as agonistic and non-agonistic interactions with conspecifics.

Group sizes within 'multi-cat' groups that were compared to singly housed cats varied both within and across studies. For example, in one study, outcome measures for singly housed cats were compared to those from cats housed in pairs (Heidenberger, 1997). In another, measures for singly housed cats were compared to those from cats housed in multi-cat groups that ranged from 2 up to 30 cats per 'multi-cat' group (Roberts et al., 2019).

**Table 4, Wellbeing outcomes associated with cat group size from the literature:** Summary of the significant\* reported links between cat group size (from n=1 to n<sub>≥</sub>2) and various wellbeing outcomes identified across the 15 reviewed studies. \*Reported links for one paper (Olm & Houpt, 1988) were purely descriptive.

<b>Poorer wellbeing outcomes linked with greater numbers of cats in home</b>	<b>Wellbeing outcomes not linked with numbers of cats in home</b>	<b>Better or less poor wellbeing outcomes linked with greater numbers of cats in home</b>
<ul style="list-style-type: none"> <li>• Greater likelihood of cats exhibiting 'behaviour problems' and states of anxiety (Heidenberger, 1997)</li> <li>• Increased house soiling and/or urinary problems (e.g. straining to urinate, vocalising when urinating, blood in urine, urethral obstruction) frequency, or over representation of house soiling (Barcelos et al., 2018; Lawson et al., 2019; Olm &amp; Houpt, 1988*; Pryor et al., 2001)</li> <li>• Increased conspecific aggression and conflict (Ramos, 2019)</li> </ul>	<ul style="list-style-type: none"> <li>• 'Behaviour problems' (Grigg &amp; Kogan, 2019)</li> <li>• House soiling (Kendall &amp; Ley, 2006; Roberts et al., 2020)</li> <li>• Conspecific aggression (Levine et al., 2005)</li> <li>• Obesity (Roberts et al., 2020)</li> <li>• Urinary cortisol to creatinine ratios (Lichensteiner &amp; Turner, 2008)</li> <li>• Faecal glucocorticoid metabolites (Ramos et al., 2012, 2013) at the group level</li> </ul>	<ul style="list-style-type: none"> <li>• Increased 'quality of life' scores and less 'problem behaviour' (Adamelli et al., 2005)</li> <li>• Fewer bites, aggressive behavior and other negative interactions with humans (Amat et al., 2009; Kendall &amp; Ley, 2006; Roberts et al., 2020;)</li> <li>• Lower faecal glucocorticoid metabolites (Ramos et al., 2013)(but only in cats aged &lt;2 and when single cats were compared with groups of 3-4)</li> <li>• Increased conspecific affiliative behaviour (Ramos et al., 2019)</li> </ul>

### 3.2. KEY FINDINGS

Overall, across the reviewed papers, results did not indicate consistent directions of relationships between numbers of cats within a household and outcome measures relevant to cat wellbeing. Four of the papers included mixed results (i.e. increases in cat group size were linked to both positive and negative wellbeing outcomes), depending on the specific outcome

in question (Kendall & Ley, 2006; Ramos, 2019; Roberts et al., 2020) or the variables outcomes were being tested against (Ramos et al, 2013). In total, six of the 15 papers provided evidence indicating greater numbers of cats within the home were significantly associated with poorer wellbeing outcomes. A total of six papers provided evidence indicating the opposite trend and a total of four papers provided evidence indicating no links between numbers of cats in the household and wellbeing outcomes (see table 4).

### 3.3. ADDITIONAL SOCIAL AND ENVIRONMENTAL MEDIATORS OF CAT WELLBEING

A range of other variables (summarised in tables 5 and 6) were reported as being significantly linked to the wellbeing outcomes measured. These included exogenous factors covering aspects of the cats' physical (e.g. outdoor access, indoor space available, litter tray provisions) and social environment (e.g. time alone, human density and level of human social activity), in addition to various endogenous factors (e.g. breed, sex, age, neuter status). Across the literature, a range of non-significant relationships between wellbeing outcomes and physical, social and cat characteristics were also identified, although these were too many to enable their concise reporting within this review (and were also considered to be largely outside of its scope).

**Table 5, Factors associated with negative wellbeing measures in the literature:** Physical, social and individual cat characteristics significantly associated with more negative cat wellbeing outcomes.

Factors relevant to cats' physical environment	Factors relevant to cats' social environment	Individual cat characteristics
<ul style="list-style-type: none"> <li>• Having outdoor access (Barcelos et al., 2018; Grigg &amp; Kogan, 2019; Levine et al., 2005), not having outdoor access (Amat et al., 2009; Barcelos et al., 2018), having a cat flap, having restricted outdoor access (Heidenberger, 1997)</li> <li>• House located in suburban area (Heidenberger, 1997), house located in rural village (Roberts et al., 2020)</li> <li>• Less space per cat available (but not absolute home size) (Heidenberger, 1997), more inside space available (but not m<sup>2</sup> per cat) (Lichtsteiner &amp; Turner, 2008)</li> </ul>	<ul style="list-style-type: none"> <li>• Owner living alone, being in a couple, being childless (Heidenberger, 1997)</li> <li>• Increased time cat left alone (Heidenberger, 1997), fewer human-cat interactions (Heidenberger, 1997; Grigg &amp; Kogan, 2019)</li> <li>• Owners having less cat knowledge (Grigg &amp; Kogan, 2019)</li> <li>• Higher number of humans in the household and more humans per meter square (Lichtsteiner &amp; Turner, 2008), socially active humans in the household (Adamelli et al., 2005), higher owner reported human-social satisfaction (Ramos et al., 2012)</li> <li>• Owner under 55 years of age (Roberts et al., 2020)</li> <li>• Owner punishing the cat (Grigg &amp; Kogan, 2019)</li> </ul>	<ul style="list-style-type: none"> <li>• Being &gt;2 years of age when in a multi-cat environment of 3-4 (Ramos et al., 2013), being younger (&lt;1year or 1-7 years) (Elzerman et al., 2019)</li> <li>• Being 2-7 years or over 12 years (Heidenberger, 1997)</li> <li>• Being male (Pryor et al., 2001), being female (Elzerman et al., 2019; Roberts et al., 2020), being female and neutered (Heidenberger, 1997), being female and intact (Amat et al., 2009; Grigg &amp; Kogan, 2019)</li> <li>• Being intact (Adamelli et al., 2005), being castrated (Heidenberger, 1997)</li> <li>• Being of mixed breed rather than pedigree (Roberts et al., 2020), being a Persian breed (Amat et al., 2009)</li> <li>• Cat being described as more 'sedentary and shy' (Elzerman et al., 2019)</li> <li>• Increased time living in the home (Elzerman et al., 2019)</li> </ul>



<ul style="list-style-type: none"> <li>• A 'low' number of litter trays provided (whether absolute or per cat unspecified), using crystal and recycled paper-type litter, trays in the same area, less frequent tray cleaning (Lawson et al., 2019)</li> <li>• Cat living in the house for &gt;6 months (Elzerman et al., 2019)</li> </ul>	<ul style="list-style-type: none"> <li>• First meetings of cohabiting cats described as unfriendly, fighting at initial introduction (Levine et al., 2005)</li> <li>• New cat introduced to house within the last six months (Elzerman et al., 2019)</li> <li>• Introduction of new cat to the household 'did not go well' (Elzerman et al., 2019)</li> <li>• Owner having degree level education (Roberts et al., 2020)</li> </ul>	<ul style="list-style-type: none"> <li>• Cat being a stray, acquired from a shelter, from friends (Heidenberger, 1997), being from a pet shop (Amat et al., 2009)</li> <li>• Being declawed (Grigg &amp; Kogan, 2019)</li> <li>• Cat described as 'tolerating' rather than 'liking' or 'disliking' being petted by owner (Ramos et al., 2013)</li> <li>• Weighing 4kg or more (Heidenberger, 1997)</li> <li>• Cat being acquired between 5 months and 1 year (Heidenberger, 1997)</li> </ul>
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**Table 6, Factors associated with positive wellbeing outcomes in the literature:** Physical, social and individual cat characteristics significantly associated with better/less poor cat wellbeing outcomes.

<b>Factors relevant to cats' physical environment</b>	<b>Factors relevant to cats' social environment</b>	<b>Individual cat characteristics</b>
<ul style="list-style-type: none"> <li>• Cat having free access to outdoors (Barcelos et al., 2018; Heidenberger, 1997), or regular access (2-3 times a week) to outdoors (Heidenberger, 1997)</li> <li>• Cat having one litter box per cat plus one, having at least one food bowl per cat (Elzerman et al., 2019)</li> </ul>	<ul style="list-style-type: none"> <li>• More experienced cat owners (Heidenberger, 1997)</li> <li>• Owners handling their cats for several hours a day, and at consistent intervals throughout the day (Heidenberger, 1997)</li> <li>• New cat introduced to house within the last six months (Elzerman et al., 2019)</li> <li>• Introduction of new cat to the household described as 'went well' by owner (Elzerman et al., 2019)</li> </ul>	<ul style="list-style-type: none"> <li>• Cat being young (&lt;1 year or 1-7 years)(Elzerman et al., 2019)</li> <li>• Cat being described as 'active and curious' by owner (Elzerman et al., 2019)</li> <li>• Cat being described as 'dependent on owner/clingy' or having a 'relaxed' demeanour (Barcelos et al., 2018)</li> </ul>

### 3.4. KEY LIMITATIONS

As in Finka et al. (2014), the substantial variation in study methodologies and reporting styles across the literature made direct between-study comparisons problematic. Amongst the reviewed studies, a series of key limitations were identified, which could typically be assigned to one of two categories: limitations relating to (i) the general scientific quality of the study design, analysis and reporting and (ii) the relevance of the study to our focused clinical question. Collectively, these limitations restricted the strength of available evidence and thus the overall conclusions that could be drawn regarding relationships between cat group size and cat wellbeing.

### 3.4.1. GENERAL SCIENTIFIC QUALITY

#### *OWNER AND CAT SAMPLING BIAS*

Owners were typically self-selecting, with recruitment methods involving advertisements within veterinary centres and universities, or via online survey sharing (Adamelli et al., 2005; Barcelos et al., 2018; Elzerman et al., 2019; Grigg & Kogan, 2019; Heidenberger, 1997; Kendall & Ley, 2006; Lawson et al., 2019; Lichtsteiner & Turner, 2008; Pryor et al., 2001; Ramos et al., 2012, 2013; Roberts et al., 2020).

Self-selection sampling, specifically through online surveys, is often associated with responder bias, with some subgroups tending to be over engaged (i.e. women) and others under engaged (i.e. the elderly or those from lower socio-economic backgrounds (Bethlehem, 2010)). Of the five studies reporting responder gender (Adamelli et al., 2005; Elzerman et al., 2019; Grigg & Kogan, 2019; Heidenberger, 1997; Kendall & Ley, 2006), all indicated higher proportions of owners identifying as female, with percentages ranging from 60.3% (Grigg & Kogan, 2019) to 96% (Kendall & Ley, 2006). No studies reported details of age distributions or socioeconomic status, therefore other responder biases may be present but unaccounted.

Many studies utilised demographic data and/or wellbeing measures from a single (Adamelli et al., 2005; Amat et al., 2009; Barcelos et al., 2018; Grigg & Kogan, 2019; Levine et al., 2005; Olm & Houpt, 1988; Pryor et al., 2001; Roberts et al., 2020 😊), or limited (Ramos et al., 2012), number of cats within each multi-cat household, as opposed to sampling all members. In some instances (e.g. Adamelli et al., 2005; Barcelos et al., 2018; Ramos et al., 2012) studies requested the owner select a focal cat from their multi-cat household to report on. Such methods may have unwittingly introduced cat sampling bias. For example, owners may have selected the cat that they were most attached to, causing more positive reporting due to 'pet enhancement' effects (El-Alayli et al., 2006). Equally, owners might have selected the cat at the extreme ends of a behaviour spectrum, such as individuals exhibiting few or many 'problematic behaviours', or those involved in a lot, or minimal, inter-cat conflict. This method of sampling therefore cannot account for potentially important variations in behaviour and wellbeing parameters within each multi-cat group, which may be a particularly pertinent issue where owner bias in focal cat selection occurs. Some studies, e.g. Grigg and Kogan (2019), pseudorandomised the focal cat by requesting participants use the cat whose name comes first alphabetically. This type of pseudo-randomisation is likely to reduce any selection bias and is likely to give a more demographically representative sample.

#### *ANALYTICAL APPROACH*

Survey-based papers typically tested large numbers of explanatory variables without specific a priori rationale provided. Through multiple statistical comparisons, five studies recognised the possibility of introducing type 1 errors (Barcelos et al., 2018; Elzerman et al., 2019; Grigg & Kogan, 2019; Kendall & Ley, 2006; Levine et al., 2005), with four subsequently adjusting their significance thresholds, primarily through Bonferroni corrections (Elzerman et al., 2019; Kendall & Ley, 2006; Levine et al., 2005). One study did not adjust the significance threshold as they posited that type 2 errors were more cause for concern than type 1, based on their study design (Barcelos et al., 2018). Small samples sizes were also recognised as a concern resulting in possible type 1 (Roberts et al., 2020) or type 2 (Lichtsteiner & Turner, 2008) errors occurring. One study did not include any statistical analysis of their data (Olm & Houpt, 1988).

For several studies, it was unclear which variables were included in the various analyses or what the response and explanatory variables were (Amat et al., 2009; Heidenberger, 1997; Kendall & Ley, 2006; Lawson et al., 2019). Subsequently, it was unclear whether certain variables had simply not been considered in the analyses performed, or whether they had, but the results were omitted due to their non-significance. In some cases, this was unclear in the main text although further details and test outputs were included within appendices or supplementary material (Barcelos et al., 2018; Roberts et al., 2020).

#### 3.4.2. STUDY RELEVANCE TO FOCUSED CLINICAL QUESTION:

##### *STATED AIM NOT SPECIFICALLY FOCUSED ON THE IMPACTS OF MULTI-CAT LIVING ON CAT WELLBEING*

Most papers did not have a specific focus on how multi-cat environments may affect cat wellbeing (Adamelli et al., 2005; Amat et al., 2009; Barcelos et al., 2018; Elzerman et al., 2019; Grigg & Kogan, 2019; Heidenberger, 1997; Lawson et al., 2019; Levine et al., 2005; Kendall & Ley, 2006; Olm & Houpt, 1988; Pryor et al., 2001). Typically, the number of cats within a household was one of many variables considered when exploring living conditions and cat management. The focus of these papers ranged from investigating factors associated with reported 'behavioural problems', (primarily house soiling or 'urinary problems' (e.g. straining to urinate, vocalising when urinating, blood in urine, urethral obstruction (Barcelos et al., 2018; Olm & Houpt, 1988; Pryor et al., 2001), to exploration of cat caretaking and management practices (Adamelli et al., 2005; Grigg & Kogan, 2019; Heidenberger, 1997; Lawson et al., 2019;). Consequently, only small portions of the analyses and subsequent results from each paper were relevant to our focused clinical question.

#### *LIMITED VALIDITY OF OUTCOME MEASURES AS INDICATORS OF WELLBEING*

All three studies that collected physiological data focused exclusively on excreted cortisol values, measured from faeces (Ramos et al., 2012, 2013) or urine (Lichtsteiner & Turner, 2008). While objective, such measures are potentially limited in their ability to provide information on the overall wellbeing of individuals due to their lack of specificity concerning emotional valence (see Otovis & Hutchinson, 2015). This limitation is particularly pertinent where parameters are not interpreted in combination with other behavioural indicators of wellbeing (Amat et al., 2016; Bjornvad et al., 2011; Stella et al., 2011), such as sickness and stress-linked behaviours or physical health indicators. Other endogenous factors not directly associated with wellbeing such as age, sex and neuter status may all potentially influence cortisol levels (Heimbürge et al., 2019) and should therefore be suitably controlled for within study designs or analyses.

For the remaining papers, wellbeing-related outcomes were predominantly based on the subjective reports of owners such as perceived cat 'problem behaviours', (Adamelli et al., 2005; Amat et al., 2009; Barcelos et al., 2018; Elzerman et al., 2019; Grigg & Kogan, 2019; Heidenberger, 1997; Kendall & Ley, 2006; Lawson et al., 2019; Levine et al., 2005; Pryor et al., 2001; Olm & Houpt, 1988; Roberts et al., 2020), how timid/confident (Kendall & Ley, 2006), timid/easy going (Ramos et al., 2013) and anxious (Grigg & Kogan, 2019; Heidenberger, 1997) the cat was, the quality of the cat-human relationship (Ramos et al., 2013) and accounts of conspecific and human-directed affiliative and agonistic behaviours (Adamelli et al., 2005; Amat et al., 2009; Elzerman et al., 2019; Kendall & Ley, 2006; Levine et al., 2005; Roberts et al., 2020). These were often based on owner observations or recollections of cats' behaviour over unspecified time periods (e.g. Adamelli et al., 2005; Amat et al., 2009; Barcelos et al., 2018; Grigg & Kogan, 2019; Heidenberger, 1997; Kendall & Ley, 2006; Olm & Houpt, 1988; Roberts et al., 2020). While cat 'problem behaviour' was one of the most commonly sampled outcome variables (Adamelli et al., 2005; Amat et al., 2009; Elzerman et al., 2019; Grigg & Kogan, 2019; Heidenberger, 1997; Olm & Houpt, 1988) this measure was mostly presented anthropocentrically, rather than being specific to cat wellbeing. As such, this measure might reflect behaviours which may or may not represent compromises to cat welfare. For example, behaviours such as furniture scratching, liveliness, destructiveness, vocalisation, escaping, roaming and hunting, may be problematic for owners (Heidenberger, 1997) but simply part of the cat's natural behavioural repertoire (Bradshaw, 2018). Other behaviours such as spraying and house soiling might indicate problems with management or care provision, although their presence may not be directly correlated with relative wellbeing (Heath, 2019).

#### *VARIATION IN 'MULTI-CAT' GROUPS AND METHODS OF COMPARISON*

There was substantial variability in the type of information provided on the total number of cats within each multi-cat group and a general lack of specificity over total numbers. Multi-cat groups were typically treated as categorical variables, ranging from pairs, 'groups of three or four', 'three or more' or from 2 to 30 individuals, depending on the study (Elzerman et al., 2019; Grigg & Kogan, 2019; Kendall & Ley, 2006; Levine et al., 2005; Lichtsteiner & Turner, 2008; Olm & Houpt, 1988; Ramos et al., 2013; Roberts et al., 2020).

Only one study provided the exact number of cats within each household sampled (Ramos et al., 2012). Five studies provided the mean number of cats per household, with or without the standard deviation (Grigg & Kogan, 2019; Heidenberger, 1997; Lawson et al., 2019; Lichtsteiner & Turner, 2008; Roberts et al., 2020), two additionally provided the range across their multi-cat households (Grigg & Kogan, 2019; Roberts et al., 2020), and one the median and interquartile range (Roberts et al., 2020). Four studies provided no information regarding the number of cats within the multi-cat households sampled (Adamelli et al., 2005; Amat et al., 2009; Barcelos et al., 2018; Pryor et al., 2001).

Analysis of multi-cat groups also varied between studies. Six papers appeared to treat single and multi-cat households as binomial variables despite likely or confirmed variation within the number of cats within each separate multi-cat home (Amat et al., 2009; Barcelos et al., 2018; Lawson et al., 2019; Pryor et al., 2001; Ramos et al., 2012; Roberts et al., 2020). Five studies split multi-cat households into discrete categories e.g. pairs, groups of 'three or four', groups of 'three or more' (Grigg & Kogan, 2019; Heidenberger, 1997; Kendall & Ley, 2006; Lichtsteiner & Turner, 2008; Ramos et al., 2013) for analysis between groups. However, these studies often excluded multi-cat households of certain sizes; one study excluded pair households and compared single to groups of three or four (Lichtsteiner & Turner, 2008), one paper excluded households of four cats or more (Levine et al., 2005) and two papers excluded households of five cats or more (Elzerman et al., 2019; Lichtsteiner & Turner, 2008). Three studies contained minimal to no statistical analysis between single and multi-cat households or multi-cat households of different sizes (Bradshaw, 1999; Levine et al., 2005; Olm & Houpt, 1988). Additionally, in two studies it was unclear how such variables were treated within the statistical analysis (i.e. binomial, discrete categories, or if the specific numbers of cats in each house were treated as continuous variables)(Adamelli et al., 2005; Heidenberger, 1997).

#### 4. GENERAL DISCUSSION

A total of 15 papers were critically reviewed to establish the current evidence base for links between cat group size (e.g. from single ( $n=1$ ) to multi-cat groups ( $n>2$ )) and wellbeing within the domestic home. Our appraisal indicated that in most cases, differences in the number of cats within households were significantly linked to various wellbeing outcomes. However, similar to Finka et al. (2014), the direction of these effects were inconsistent, and in some cases apparently contradictory (e.g. larger group sizes were associated with more (Heidenberger, 1997) but also less (Adamelli et al., 2005) 'problem behaviour'). This is perhaps unsurprising given the diverse methodological approaches used, which resulted in large variations in sample sizes, population demographics, variables measured and types of analyses performed, as well as the style and detail of general reporting. In particular, the lack of specificity of, or variations in, the size of cat groups being compared, as well as the diversity of outcome measures sampled and their limitations as indicators of wellbeing, made between study comparisons difficult. Thus, whilst findings from various studies may appear contradictory (i.e. Adamelli et al., 2005; Heidenberger, 1997) the details included within their methodological and statistical reporting meant it was not possible to make anything other than surface level comparisons.

For most papers, assessing the impact of cat group size on wellbeing was not the primary aim of the study. Thus, where significant links were identified, these were often a result of multiple testing between variables and wellbeing outcomes, in most cases with limited biological rationale or justification provided. Where methodological reporting made it unclear which variables had been tested (Amat et al., 2009; Heidenberger, 1997; Kendall & Ley, 2006; Lawson et al., 2019), it is reasonable to assume only significant results were reported, given the systemic bias towards significance reporting across scientific disciplines (Eastbrook et al., 1991; Fanelli, 2010; Hasenboehler et al., 2007). Whilst type 1 errors associated with multiple testing may be avoided by performing Bonferroni corrections (e.g. Elzerman et al., 2019; Kendall & Ley, 2006; Levine et al., 2005), this may in turn increase the probability of type 2 errors, particularly in studies using small sample sizes (e.g. Barcelos et al., 2018), see Nakagawa (2004). Therefore, providing a clear rationale for all tests conducted, combined with clear reporting of effect sizes and p values for each, may be preferable to performing power reducing corrections and selective result reporting (Nakagawa, 2004). Collectively, the limited cross-study comparability, inconsistency in the direction of relationships identified, potential omission of non-significant (but relevant) results, combined with the likelihood of both type 1 and type 2 errors, all serve to limit the strength of relevant evidence and thus our current understanding of this topic.

While we highlight the limited scope of the wellbeing-linked measures sampled and their reliability and validity as indicators of cat welfare, we acknowledge that assessing cat wellbeing was not the primary aim of most papers. Therefore, our criticisms relating to measure quality are more to highlight important considerations for future research. These should ideally take a triangulated approach to wellbeing assessment (Otovic & Hutchinson, 2015; Webster, 2008) and avoid the reliance on single measures in order to infer welfare (e.g. Lichtsteiner & Turner, 2008; Ramos et al., 2013). Cat wellbeing may be optimally investigated by incorporating a range of both subjective and objective measures, across physical, behavioural and biological parameters, utilising validated tools where they exist (e.g. Delgado & Reevy, 2018; Freeman et al., 2016). Measures should also be considered relative to their ability to capture welfare compromise or stress levels across suitable time periods. For example, cortisol concentrations taken from hair samples might give an indication of blood cortisol responses over a longer period than faeces or urine, although each method of cortisol sampling comes with various limitations (Otovic & Hutchinson, 2015). An absence of negative wellbeing-outcomes may not necessarily indicate an optimum welfare state or good quality of life (Green & Mellor, 2011) The presence of behaviours or indicators associated with positive anticipation, play, affiliative social behaviour, relaxation and contentment should therefore also be included (Boissy et al., 2007; Mellor & Beausoleil, 2015) to provide a more holistic view of individual wellbeing.

As in Finka et al. (2014), a range of social, environmental and cat-specific factors outside of cat group size were found to be significantly linked to the wellbeing outcomes of interest (see table 2 and 3), suggesting these complex, multifactorial relationships extend beyond free-living and rescue contexts and into the domestic home. However, differences in the variables collected across studies, as well as their direction of effects, made it difficult to form firm conclusions on specific risk factors for cat wellbeing in these contexts. Furthermore, the stability and generalisability of most findings to broader populations of cats and their owners is unclear, given the presence of sampling biases (e.g. gender skew, participant and cat selection, sampling limited to specific geographic regions).

What these results do highlight is the importance of considering a range of variables as potential confounds or covariates when investigating links between cat group size and wellbeing in the domestic home. Based on our current understanding of observations from both free-living and confined environments, these should consider available space per cat (Gouveia et al., 2011; Loberg & Lundmark, 2016), resource availability and distribution (Damasceno & Genaro, 2014), as well as the composition and characteristics of multi-cat groups. For cat characteristics and group compositions, their sex and sex ratios (Barry & Crowell-Davis, 1999; Van den Bos, 1998),



socialisation history with conspecifics (Kessler & Turner, 1999), relatedness and familiarity (Barry & Crowell-David, 1999; Bradshaw & Hall, 1999; Curtis et al., 2003), as well as the nature of conspecific relationships (i.e. generally affiliative, agonistic, tolerant or avoidant) and individual personality are potentially all important.

It is also worth noting that across studies, humans' behaviour, both that directed towards the cat and towards other humans, was frequently linked to wellbeing outcomes. For example, the cat receiving fewer interactions with humans (Grigg & Kogan, 2019) and being left alone for longer periods (Heidenberger, 1997) were associated with more reported 'behaviour problems' and anxiety respectively. However, in other studies, increased human presence in the home and higher levels of human social activity were associated with higher urinary (Lichtsteiner & Turner, 2008) and faecal cortisol (Ramos et al., 2012) concentrations. Additionally, higher faecal cortisol concentrations were identified amongst cats described as 'tolerating' rather than 'liking' or 'disliking' being petted by their owners (Ramos et al., 2013). However, as previously highlighted (e.g. Otovic & Hutchinson, 2015), such physiological measures should be interpreted with caution, especially when considered in isolation from relevant behavioural indicators. While scientific investigations into the impacts of the human-social environment upon cat wellbeing and their underpinning mechanisms are still in their infancy (e.g. Adamelli et al., 2005, Finka et al., 2019 (see also Serpell, 2019)), it is likely that they may also act as important mitigators of cat wellbeing in the domestic home.

## 5. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The current body of evidence did not indicate consistent directions of effects regarding cat group size and outcome measures relevant to wellbeing. These results highlight the potentially complex, multifactorial relationships between cat wellbeing and various social and environmental factors. Such factors may be as, if not more, important to consider than simply the number of cats residing together within a household.

However, given the paucity of current literature investigating the impact of group living on the wellbeing of cats within the domestic home, further research is required to provide a larger, better quality, evidence base. Whilst several studies produced seemingly contradictory findings, it is possible that these are a function of the substantial variation in methodological approaches used as well as the cat owner populations and wellbeing-linked measures sampled.

While cross-sectional survey designs (the most commonly used method within this review, see table A3) potentially offer a practical way to sample large international populations, they are limited in their ability to identify causality amongst variables of interest and are notorious for

sampling biases (Bethlehem, 2010). Considering the nature of the research topic (e.g. cats residing in the homes of private citizens), Randomised Controlled Trials (RCTs) are unlikely to be feasible for future exploration of the relationship between cat wellbeing and group size in these contexts. Large (ideally matched) cohort studies comprising of populations with demographic features that support generalisability of findings, may therefore be the next best option in terms of evidence quality (Brighton et al., 2003). For example, studies following a large population of cats over a substantial length of time, ideally from birth, with data gathered at regular times points.

Such studies should aim to collect suitably valid measures of cat wellbeing. However, we acknowledge that this is not without its challenges, given the limitations associated with physiological measures, subjective owner reports of cats' behaviour and the need for practical measures. We would also suggest the collection of other potentially important social and environmental parameters (see above). Such information could be used to provide sufficient demographic context regarding study populations to support effective cross study comparison, or ideally, be included as possible covariates or random effects along with the main explanatory variable (e.g. group size) within statistical analyses. Treating numbers of individuals within each household sampled as continuous rather than categorical variables, or at least more balanced group sizes within discreet categories, will likely provide a more sensitive measure of cat group variation and potential links to cat wellbeing. Lastly, it is recommended that studies provide clear rationale for the inclusion and subsequent testing of all response and explanatory variables, as well as the full reporting of all test statistics, even when not significant.

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# CHAPTER THREE: INDOORS OR OUTDOORS? AN INTERNATIONAL EXPLORATION OF OWNER DEMOGRAPHICS AND DECISION MAKING ASSOCIATED WITH LIFESTYLE OF PET CATS

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RFW – Methodology; survey creation; data collection; data cleaning; thematic analysis; quantitative data analysis; results; discussion; writing; redrafting.

LRF – Supervision and guidance.

SJW – Supervision and guidance.

MJF – Supervision and guidance.

## 1. INTRODUCTION

The provision of outdoor access for domestic cats (*Felis catus*) by their owners is a divisive issue (Abbate, 2019; Tan et al., 2020) and likely influenced by cultural norms. In the United States of America (USA), 63% of domestic cats are kept entirely indoors (PR Newswire, 2013). In contrast, many European countries, including the United Kingdom (UK) (PSDA, 2015) and Denmark (Sandøe et al., 2017), as well as Australia (Elliott et al., 2019; Toribio et al., 2009), typically provide owned domestic cats with outdoor access, in addition to allowing them to occupy the house. There is, however, a growing trend towards keeping cats exclusively indoors. The UK is seeing a rapid increase in the number of indoor-only cats, with the PSDA (People's Dispensary for Sick Animals) producing estimates of 15% in 2011, increasing to 24% in 2015 (PSDA, 2015), and a more recent UK study indicating 26.1% in 2019 (Finka et al., 2019).

At present, very little information exists regarding the factors that owners consider when deciding on a lifestyle for their cat, the weight owners assign to these factors, or if specific cat and owner demographic variables are associated with different lifestyles. This information could be of benefit to organisations, charities, or individuals to maximise the efficacy of human behaviour change incentives. It may also help to explain changes in cat management trends globally and predict how management trends may continue to change in the future.

For this study, a survey was distributed to an international population of current cat owners, exploring the rationales behind lifestyle choices for cats. To help inform survey questions, an initial overview of the current literature surrounding the factors that owners may consider when making a lifestyle decision for their cat was generated. This review is presented below.

### 1.1. LIFESTYLE CONSIDERATIONS

Hunting: Domestication of the cat was driven by their predatory nature, which was advantageous for pest control in early agricultural communities (Driscoll et al., 2009). Since then, cats have experienced a relatively unique domestication process involving less intensive selection than animals such as dogs (Driscoll et al., 2009). Consequently, most domestic cats have retained ancestral behavioural motivations, such as hunting drive irrespective of food provision (Bradshaw, 2018). Whilst hunting behaviour is still valued in some agricultural contexts, it is not typically valued by owners keeping cats as companions (Crowley et al., 2019; Hall et al., 2016). On the contrary, predatory behaviours are of growing concern as the numbers of domestic cats rise due to their impacts on native wildlife including birds, invertebrates, mammals, and amphibians (Blancher, 2013; van Heezik et al., 2010). The ecological impact of hunting on wildlife appears to vary between areas. More severe damage to ecosystems is

thought to occur where cats represent an introduced predator and where wildlife has not evolved to avoid predation, such as Australia, New Zealand, or remote islands. In some such instances, cats have been credited as contributors to the extirpation or near-extirpation of species (Bonnaud et al., 2015; Murphy et al., 2019; Woinarski et al., 2011). Consequently, some owners, at the behest of wildlife charities and veterinarians, opt to keep cats indoors to prevent hunting (McLeod et al., 2015). It is possible that concerns over impact severity may influence the consideration given to hunting by owners. For example, UK cat owners generally disagree that cats are harmful to wildlife, regardless of the predatory behaviour of their cat (McDonald et al., 2015). In Australia and New Zealand, however, 62% and 51% of cat owners, respectively, agree that predation is problematic (Hall et al., 2016).

Cat safety: Outdoors, road-traffic accidents (RTAs) are likely a major concern to cat owners. A UK study found the major cause of mortality for cats brought into a veterinary clinic was trauma, 60% of which were identified as RTAs (O'Neill et al., 2015). An estimated 12% of cats in Cambridgeshire, UK had been involved in an RTA and survived (Rochlitz, 2003), suggesting a higher percentage of cats are involved in RTAs in total when also accounting for mortalities. Additional outdoor risks include attacks by humans, and where feral cats are considered as pests and lethally controlled, domestic cats may risk being indiscriminately killed through poisoning (Ratcliffe et al., 2010) or other pest control methods. There is also the potential to consume toxins such as pesticides, insecticides, anti-freeze, or toxic outdoor plants. Indoors, cats may ingest toxic substances, such as cleaning products, houseplants or flowers, medicines, or toxic food substances (Berny et al., 2010), or risk electrocution from household appliances. Both indoors and outdoors, there is a possibility of injuries or bites from wild and domesticated animals, including other cats (Lund et al., 1999).

Physical health: A positive correlation between obesity in cats and an indoor-only lifestyle has been demonstrated, with potential mechanisms cited as being a reduced physical activity, greater consumption of food through boredom, and lack of enrichment (Robertson, 1999; Rowe et al., 2015; Wall et al., 2019). Obesity, reduced activity, and toileting exclusively indoors have also been associated with increased risk of feline urological syndrome (FUS) (Buffington, 2002). It is possible some owners may utilise outdoor access as a weight management tool. Outdoors, however, cats are at greater risk of contracting diseases such as feline immunodeficiency virus (FIV), feline leukaemia virus (FeLV), ringworm and cat flu, or parasites due to their contact with wildlife and other domestic cats (Chalkowski et al., 2019). Owners may wish to reduce these risks to improve welfare or prevent associated veterinary treatment or zoonotic transmission.

Additionally, owners of cats with contagious diseases may choose to house their cats indoor-only to prevent disease transmission to other cats.

Mental well-being: Many behavioural needs of cats, such as hunting, territorial patrolling and marking, roaming, and climbing may be more readily met in an outdoor environment (Bradshaw, 2018). Whilst owners may instead aim to meet their cat's behavioural needs indoors, studies suggest many cat owners may not provide adequate levels of enrichment to ensure high welfare for their cat (Grigg & Kogan, 2019; Lawson et al., 2019; Toukhsati et al., 2012). Insufficient levels of enrichment and the inability to avoid stressful human-social environments indoors (Adamelli et al., 2005; Ramos et al., 2012) may contribute towards the comparatively higher levels of undesirable and sickness behaviours observed in indoor-only cats, compared to indoor-outdoor cats (Amat et al., 2009.; Finka et al., 2019; Heidenberger, 1997; Sandøe et al., 2017; Schubnel & Arpaillange, 2008), although it has been reported in one instance that indoor-outdoor cats may display more undesirable behaviours (Grigg & Kogan, 2019). With regards to owner attitudes, an Australian study revealed most indoor-outdoor cat owners felt wandering was natural and necessary for cats to be 'happy' (McLeod et al., 2015). In the USA, owners were mixed in their response when asked if cats needed time outdoors to be 'happy' (Grigg & Kogan, 2019). In a Brazilian study, just 7.5% of owners felt it was necessary for cats to have outdoor access (Machado et al., 2020). Whilst owners may perceive some aspects of outdoor access as beneficial to cat mental health, it must be considered that owners interpret other aspects as detrimental, lest their cats perceive potential dangers, novel environments, sights, and sounds or territorial conflicts with conspecifics negatively.

## 1.2. AIMS AND OBJECTIVES

- Identify if different owner features or cat demographics are associated with greater odds of cats having an indoor-only or indoor-outdoor lifestyle
- Elucidate the extent to which factors identified from the literature influence owners when making lifestyle decisions for their cat, and what proportion of owners consider the different lifestyle options available
- Establish major narrative themes around owner decision making

## 2. MATERIALS AND METHODS

### 2.1. SURVEY CREATION AND DISTRIBUTION

An initial online survey (part 1) for cat owners was distributed in English via social media, predominantly Facebook and Twitter, between February 2019 and April 2019 (see appendix,

A3). It purposively sampled cat owners using relevant social media groups and cat-related hashtags. To participate, respondents needed to be 18 years old or over and the current owner of at least one cat which did not live exclusively outdoors. Cats living exclusively outdoors were excluded as this form of caretaking is often associated with farm, community or feral cats, where the owners may not make an active decision to provide an exclusively outdoor lifestyle, but rather the cat already existed within that environment when the owner came to care for them. Population sizes are also likely to be much smaller than cats who live within the home, and caretakers may not identify themselves as the owners of these cats, reducing the likelihood of receiving a sample significant enough to analyse.

The survey comprised of the following sections: owner demographics, cat demographics, cat health and behaviour (including both sickness and undesirable behaviours), cat personality, cat lifestyle (indoor-outdoor or indoor-only) and the basic rationale for said lifestyle, home environment inclusive of basic provisions and enrichment and social behaviour with adults, children, and cats and dogs within the household. Questions consisted of multiple and single choice questions, Likert scales, and open-ended text-based questions.

Participants who responded to the initial survey (part 1)(see appendix, A3) and had provided an email address were sent a second survey (part 2) exploring the rationale for choosing an indoor-only or indoor-outdoor lifestyle for their cat (see appendix, A4 and A5). Through a series of questions, owners were asked to identify factors influencing their decision and the strength of their consideration using Likert scales. Factors that were hypothesised to influence owner decision making obtained from the literature were provided, and an 'other' option was provided where owners could indicate additional considerations. The rationales included for providing or considering an indoor-only lifestyle were to prevent hunting, to protect the cat from people, to protect the cat from traffic, to protect the cat from other cats, to protect the cat from wildlife and that the cat has health issues. Reasons provided for why owners might provide/consider an indoor-outdoor lifestyle were potential benefits to mental health, potential benefits to physical health, the cat toilets outside, the cat provided pest control, and the cat indicates they want outdoor access.

Part 2 of the survey also established if owners of indoor-only cats had considered outdoor access and vice versa and identified the strength of consideration given to aspects of the alternative lifestyle. Respondents were encouraged to leave as many details as possible in open-ended questions. Owners of both indoor-only and indoor-outdoor cats answered the same questions,

reworded to be appropriate to each group. Responses from part 1 and part 2 were matched using email addresses, so demographic data could be associated with rationales.

Ethical approval was given by Nottingham Trent University School of Animal, Rural and Environmental Sciences Research and Ethics Committee on the 11<sup>th</sup> December 2018 (ARE843).

## 2.2. DATA CLEANING

In total, 5129 usable responses were obtained for part 1 of the survey. In addition to the usable responses, owners who indicated they intended to change their cat's lifestyle were excluded from the analysis ( $n = 34$ ). These owners detailed reasons such as recently acquiring their cat, recently moving to a new house, or having a cat they deemed as currently too young to roam, including those awaiting neutering. Owners providing different answers for their cats' lifestyles for part 1 and part 2 of the survey but who had not indicated they had changed their cat's lifestyle were excluded to avoid reporting errors by respondents ( $n = 16$ ). Finally, those who had categorised their cat as having one lifestyle but provided contradictory comments were excluded ( $n = 43$ ), e.g., one owner indicated their cat was indoor-only but commented, 'The cat does have some supervised time outside [...]'.

Owners were categorised into three major regions—Europe, USA and Canada, and Australia and New Zealand. Other regions were excluded from analyses due to low sample sizes ( $n = 154$ ). These regions were chosen to compare attitudes towards cat management which might be influenced by variations in local legislation and recommendations from regional feline welfare charities (ASPCA, 2020; Cats Protection, 2015; Australian Government, 2015).

## 2.3. DATA ANALYSIS

Responses were divided into populations of owners providing their cats with either an indoor-only or indoor-outdoor lifestyle. A combination of Microsoft Excel (Version 2002, Microsoft, Washington, DC, USA) and IBM SPSS (Version 26, New York, NY, USA) was used to generate descriptive statistics exploring the demographics of cats with different lifestyles. Descriptive statistics were also used to gain insight into the frequency of responses from quantitative multiple-choice questions.

Open-ended responses were read in their entirety by the lead author, RFW. A portion of open responses directly reflected the multiple-choice answers provided and was coded as such. Responses that did not fit existing answers were classed as 'other' reasons within quantitative analyses. These 'other' responses were taken forward to an additional qualitative thematic analysis and coded as new semantic themes, using the six-phase methodology defined by Braun



and Clarke (Braun & Clarke, 2006). In keeping with qualitative methods and considering that responses were optional and therefore not balanced amongst key owner and cat demographic variables, themes were not quantified. Themes and example responses are instead provided to allow insight into the wide range of factors owners may consider when choosing their cats' lifestyle, alongside the depth of thought and emotion behind these considerations.

## 2.4. ODDS RATIOS

Demographic variables hypothesised to have biological relevance to owner decisions on cat lifestyle choice were explored using binary logistic regression modelling. Odds ratios were calculated to elucidate if specific variables predicted a greater likelihood of an indoor-outdoor or indoor-only lifestyle. Three models were produced, each with 'lifestyle' as the response variable.

Model one explored associations between lifestyle and owner social features, with explanatory variables of owner gender, owner age, and the number of other cats, dogs, and children (17 years old and under) in the home. It was hypothesised that owners of different generations with differing levels of social intensity within their homes may make different lifestyle choices for their cats.

Model two's explanatory variables were cat features of age, sex, ongoing health issues, and pedigree status. It was hypothesised owners may make decisions based on the specific characteristics of their cat and what they deemed to be the most appropriate lifestyle for that individual. Cat ages were categorised into life stages for analysis, based on definitions provided by Vogt et al. (2010), which are as follows: kitten, 0–6 months old; junior, 7 months–2 years old; adult, 3–6 years old; mature, 7–10 years old; senior, 11–14 years old; super senior, 15+ years old. Due to the small numbers of super senior cats in the sample, these cats were grouped with senior cats to create a senior category of 11+ years old. Age was not treated as a continuous variable due to owners often being unsure of the precise age of their cat, particularly if acquired from rehoming centres or through adopting a stray. As behavioural differences are most likely to be seen between cats in different lifestages, using this variable as categorical was deemed to be biologically relevant. Neutering, microchipping, vaccinating, and declawing were not deemed to be biologically relevant explanatory variables for this model. Whilst there may be correlation between these variables and certain lifestyles, it was deemed more plausible that lifestyle choice would impact the decision of owners to provide such treatments to their cats, e.g. if an owner was inclined to let their cat outdoors they would vaccinate the cat before doing so, rather than

vice versa, or an owner inclined to keep their cat as indoor-only would not let them outdoors just because they are neutered.

Model three explored geographic features and consisted of explanatory variables of the global region, area type, e.g., rural, urban, etc.; and dwelling type, e.g., flat/apartment, detached house, etc. It was hypothesised that differing cultural norms may impact lifestyle choices between regions, and that area and dwelling type may influence owners based on the availability and quality of outdoor access.

Reference categories were set as the normative categories. For owner gender, cat sex, owner and cat age, region, area, and dwelling type these were the variable category with the largest portion of respondents. For the presence of other cats, dogs, under 17-year-olds, health issues, or pedigree status, the reference categories were set as 'no'.

Due to small group sizes making for unbalanced categories, excluded from the analysis were owners who had indicated 'prefer not to say' for either age or gender, owners identifying as 'other' for gender, owners unsure of their cats' sex or age, owners living in movable homes such as motorhomes or barges, one owner who indicated they lived in a Souterrain (cellar), and kittens <6 months old. If responses were excluded, they were excluded across all three models. In total, 4909 samples out of the original 5129 were analysed.

### 3. RESULTS

From the first part of the survey, 5129 responses were included. Part 2, exploring lifestyle rationales in more depth, was emailed to all participants from the initial survey who had provided an email address (2581/5129) and was returned by 459/1071 of indoor-only respondents (response rate 46.4%) and 595/1510 of indoor-outdoor respondents (response rate 39.4%). As not every question was answered by all participants due to survey routing, the number of respondents is detailed with each result presented within this section.

#### 3.1. DEMOGRAPHIC RESULTS

Of the initial 5129 survey respondents (prior to those excluded for the odd ratios analysis), most respondents were female (89.1%), 26–35 years old (28.2%), had no children under 17 years old living with them (80.4%), owned more than one cat (55.3%), and had no dogs (81.8%). Most respondents lived in Europe (76.2%), falling across 36 European countries in total, although the majority were UK-based (80.3%). A full breakdown of owner demographics can be seen in table 7, divided into populations of owners that provided either indoor-only or indoor-outdoor environments for their cats.

The 5129 cats answered for were relatively evenly split between sex, with 50.6% being female. The majority were neutered (96.8%), microchipped (79.0%), up to date with relevant vaccinations by the owner's definitions (75.4%), not declawed (97.9%), and had no health problems (83.4%). A full breakdown of cat demographics and the split between indoor-only and indoor-outdoor cats can be seen in table 8.

### 3.2. VARIABLES AS PREDICTORS OF LIFESTYLE (ODDS RATIOS)

Of the 12 major variables tested across the three described models, 10 were found to be significantly associated with cat lifestyle. Full details can be found in tables 9-11, whilst a summary is provided below.

Variables with greater odds of cats having an indoor-only lifestyle were owners who were 26–35 years old ( $p < 0.001$ , OR 0.765) when compared to those 36–45 years old, cats in multi-cat households ( $p < 0.001$ , OR 0.768) compared to single cat households, junior cats ( $p < 0.001$ , OR 0.656) when compared to adult cats, pedigree cats ( $p < 0.001$ , OR 0.441) or those whom owners were unsure of their pedigree status ( $p < 0.004$ , OR 0.707) compared to non-pedigree cats, cats with health issues ( $p < 0.001$ , OR 0.596) compared to cats with no health issues, living in city centres ( $p < 0.001$ , OR 0.442) or urban areas ( $p < 0.001$ , OR 0.730) when compared to suburban areas, and living in the USA and Canada ( $p < 0.001$ , OR 0.093) or Australia and NZ ( $p < 0.001$ , OR 0.510) when compared to living in Europe.

**Table 7, Owner demographics of survey responses:** Owner demographics and their living environments of the 5129 respondents. Percentages for the entire group of respondents are shown, as are the breakdowns between those who indicated their cat had an indoor-only ( $n = 2104$ ) or indoor-outdoor lifestyle ( $n = 3025$ ).

<b>Owner Demographics</b>	<b>Categories</b>	<b>Proportion of Total Population (%) (<math>n = 5129</math>)</b>	<b>Proportion of Indoor-Only Population (%) (<math>n = 2104</math>)</b>	<b>Proportion of Indoor-Outdoor Population (%) (<math>n = 3025</math>)</b>
<b>Owner gender</b>	Female	89.1	87.9	89.9
	Male	9	9.5	8.7
	Other	1.2	1.9	0.7
	Prefer not to say	0.7	0.7	0.8
<b>Owner age</b>	18–25	14.1	14.3	14
	26–35	28.2	33.2	24.8
	36–45	23.7	23.2	24
	46–55	20	17.5	21.8
	56+	12.6	11.5	15
	Prefer not to say	0.4	0.3	0.5
<b>Other cats</b>	No	44.7	41.8	46.6
	Yes	55.3	58.2	53.4
<b>Dogs</b>	No	81.8	83.1	80.9
	Yes	18.2	16.9	19.1
<b>Children (17 and under)</b>	No	80.4	84.2	77.4
	Yes	19.6	15.2	22.6
<b>Region</b>	Europe	76.2	30.2	69.8
	USA and Canada	20.8	80.6	19.4
	AUS and NZ	3	42.2	57.8
<b>Area</b>	City centre	9.2	15.4	4.8
	Urban	20.1	24	17.4
	Suburban	41.9	38.9	44
	Village	16.9	11.5	20.7
	Rural	11.9	10.2	13.2
<b>Dwelling Type</b>	Flat/studio/apartment	20.6	37.5	8.8
	Terrace/town/row house	18.1	12.9	21.8
	Semi-detached	27.8	17.2	35.1
	Detached	27	26.2	27.5
	Bungalow/cottage	5.9	5.2	6.4
	Other	0.7	0.9	0.5

**Table 8, Cat demographics of survey responses:** Cat demographics and their management practices as reported by 5129 owners. The percentages for all cats can be seen, alongside a breakdown of those with an indoor-only lifestyle ( $n = 2104$ ) and an indoor-outdoor lifestyle ( $n = 3025$ ).

<b>Cat Demographics</b>	<b>Categories</b>	<b>Proportion of Total Population (%) (<math>n = 5129</math>)</b>	<b>Proportion of Indoor-Only Population (%) (<math>n = 2104</math>)</b>	<b>Proportion of Indoor-Outdoor Population (%) (<math>n = 3025</math>)</b>
<b>Cat age</b>	Kitten (0–6 months old)	1	1.7	0.4
	Junior (7 months –2 years old)	26	20.2	12.6
	Adult (3–6 years old)	33.1	43.3	43.3
	Mature (7–10 years old)	21.1	15.4	17.4
	Senior (11+ years old)	18.3	19	25.8
	Unsure	0.5	0.4	0.5
<b>Cat sex</b>	Female	50.6	51.9	49.6
	Male	49.3	48	50.2
	Unsure	0.1	0	0.2
<b>Health problems</b>	Yes	16.6	19.3	14.7
	No	83.4	80.7	85.3
<b>Pedigree</b>	Yes	11.2	16	7.9
	No	82.3	76.5	86.4
	Unsure	6.5	7.6	5.8
<b>Neutered</b>	Yes	96.8	95	98
	No	2.8	4.8	1.4
	Unsure	0.4	0.2	0.6
<b>Microchipped</b>	Yes	79	71.4	84.3
	No	19.8	27.4	14.5
	Unsure	1.2	1.2	1.2
<b>Vaccinated</b>	Yes	75.4	75.2	75.5
	No	20.8	21	20.7
	Unsure	3.9	3.9	3.9
<b>Declawed</b>	Yes	2.1	4.2	0.1
	No	97.9	95.7	99.4
	Unsure	0	0.1	0

**Table 9, Odds ratios model 1 – owner demographics:** Results of 4909 owner household variables tested through binary logistic regression for their association with cat lifestyle. Owners with increased odds of providing outdoor access are indicated by an odds ratio (OR) greater than one, whilst an OR lower than one indicates owners with increased odds of keeping cats as indoor-only.

Owner Household Variables	Sub-Group	Probability	OR	95% Confidence Interval (CI)
Owner gender	Female		Reference	
	Male	0.231	0.886	0.727–1.080
Owner Age	18–25	0.943	0.993	0.815–1.209
	26–35	0.001	0.765	0.651–0.898
	36–45		Reference	
	46–55	0.006	1.281	1.073–1.529
	56+	<0.001	1.499	1.224–1.836
	Children	No		Reference
	Yes	<0.001	1.707	1.461–1.995
Other cats	No		Reference	
	Yes	<0.001	0.768	0.683–0.865
Dog	No		Reference	
	Yes	0.078	1.149	0.984–1.340

**Table 10, Odds ratios model 2 – cat demographics:** Results of 4909 cat variables tested through binary logistic regression for their association with cat lifestyle. Cat features that increase their odds of being provided outdoor access are indicated by an OR greater than one, whilst an OR lower than one indicates cat features that increase odds of being kept as indoor-only.

Cat Variables	Sub-Group	Probability	OR	95% CI
Sex	Female		Reference	
	Male	0.016	1.155	1.028–1.298
Age	Junior	<0.001	0.656	0.565–0.762
	Adult		Reference	
	Mature	0.047	1.179	1.002–1.386
	Senior	<0.001	1.445	1.211–1.724
	Pedigree	No		Reference
	Unsure	0.004	0.707	0.559–0.894
	Yes	<0.001	0.441	0.367–0.529
Health Issues	No		Reference	
	Yes	<0.001	0.596	0.507–0.700

Variables found to have greater odds of being associated with an indoor-outdoor lifestyle were owners being 46–55 years old ( $p$  0.006, OR 1.281) or 56+ years old ( $p$  < 0.001, OR 1.499) when compared to those 36–45 years old, owners with children (17 years old or under) living at home ( $p$  < 0.001, OR 1.707) when compared to those without, cats being male ( $p$  0.016, OR 1.155) compared to being female, and cats being mature ( $p$  0.047, OR 1.179) or senior ( $p$  < 0.001, OR 1.445) when compared to adult cats.

**Table 11, Odds ratios model 3 – geographical variables:** Results of 4909 area variables tested through binary logistic regression for their association with cat lifestyle. Geographical variables where owners have increased odds of providing outdoor access are indicated by an OR greater than one, whilst an OR lower than one indicates geographical variables where owners have increased odds of keeping cats as indoor-only.

Area Variables	Sub-Group	Probability	OR	95% CI
Area	City centre	<0.001	0.442	0.341–0.574
	Urban	0.001	0.730	0.607–0.877
	Suburban	Reference		
	Village	0.796	0.974	0.801–1.186
	Rural	0.223	1.154	0.916–1.454
House Type	Flat/studio/apartment	<0.001	0.199	0.162–0.245
	Terrace/town/row house	0.165	0.868	0.711–1.060
	Semi-detached	Reference		
	Detached	0.385	1.093	0.894–1.336
	Bungalow/cottage	0.637	1.079	0.787–1.478
Region	Europe	Reference		
	USA and Canada	<0.001	0.093	0.076–0.114
	Australia and NZ	0.001	0.510	0.349–0.746

### 3.3. LIFESTYLE CHOICE RATIONALE

#### 3.3.1. INDOOR-ONLY OWNERS

Of owners of indoor-only cats, 73.1% (1538/2104) indicated the lifestyle was their preference, 18.7% (393/2104) indicated they did not have the option to provide their cat with outdoor access, and 8.2% (173/2104) reported their cat chose not to go out even when given the choice. As seen in table 12, a total of 85% (1133/1333) of the major reasons given for choosing an indoor-only lifestyle pertained to cat safety, not inclusive of additional reasons provided for the ‘other’ category.

Protection from traffic was the largest influencing factor for owners across all three regions. It was cited as the major reason (i.e. the reason that had the most influence over an owners

decision) for choosing an indoor-only lifestyle by most indoor-only owners at 58.7% (782/1333), and 98.7% (1435/1454) of indoor-only owners were influenced by traffic to some extent when making their decision, with 86.7% (1261/1454) saying traffic was a strong factor in their decision. The second major reason for indoor-only owners choosing this lifestyle varied between regions. Owners in Europe cited it to be protection from people (18.1%, 117/645), the USA and Canada cited protection from wildlife (19.9%, 126/634), and owners in Australia and New Zealand cited it was to prevent cats hunting (29.6%, 16/54).

**Table 12, Factors indoor-only cat owners considered when choosing lifestyle:** The percentages of indoor-only cat owners ( $n = 1454$ ) reporting different strength of factors on their decision to give their cats an indoor-only lifestyle and the major reasons for choosing an indoor-only lifestyle globally ( $n = 1333$ ), then broken down by region.

Factors	Strength of Influence on Decision of Indoor-Only Cat Owners ( $n=1454$ ) (%)					Major Reason Lifestyle Was Chosen by Indoor-Only Owners (%)			
	None	Weak	Some	Mod.	Strong	Global ( $n=1333$ )	USA & Can. ( $n=634$ )	Europe ( $n=645$ )	AUS & NZ ( $n=54$ )
Prevent hunting	41.5	18	14.7	9.1	16.8	3.8	4.1	1.4	29.6
Protect from people	11.6	7.4	14.8	17.4	48.8	13.4	9.3	18.1	5.6
Protect from traffic	1.3	1.2	3.8	7	86.7	58.7	51.6	67.1	40.7
Protect from other cats	12.9	12.4	18.5	19.3	37	2.9	3.6	2.5	0
Protect from wildlife	19.9	13.4	13	13.9	39.8	10	19.9	0.5	7.4
Cat has health issues	79	6	4.6	3.1	7.3	2.6	1.9	3.3	1.9
Other	-	-	-	-	-	8.6	9.6	7.1	14.8

Of indoor-only owners, 71.5% (328/459) said they had not considered the alternative of an indoor-outdoor lifestyle. Indoor-only owners who did consider the alternative lifestyle were asked what the major reason they would change lifestyle would be, and 35.3% (46/131) cited



the potential benefits to mental health. Overall, 96.1% (126/131) of indoor-only owners considering an indoor-outdoor lifestyle considered potential mental health benefits of outdoor access in some capacity, with 57.3% (75/131) of owners considering this strongly. More details can be found in table 13.

### 3.3.2. INDOOR-OUTDOOR OWNERS

For indoor-outdoor owners, the benefit of outdoor access to mental health was the major cited reason for allowing cats outdoor access at 38% (226/595). The second most cited reason was that the cat indicates they want to go outside at 32.9% (196/595). A global breakdown for indoor-outdoor owners is not provided as it is for indoor-only owners, as although part 2 of the survey was distributed to owners in all regions, all owners who responded resided in Europe.

Of indoor-outdoor owners, 70.8% (421/595) said they had not considered the alternative of an indoor-only lifestyle. Of those who did, traffic was again considered a risk. Of indoor-outdoor cat owners who contemplated an indoor-only lifestyle, 96.6% (168/174) considered traffic, with 74.1% (129/174) stating this was a strong consideration. Protection from traffic was the most cited reason owners would switch to an indoor-only lifestyle at 45.8% (80/174). More details on owners who considered an indoor-only lifestyle can be found in table 14.

**Table 13, Factors indoor-outdoor cat owners considered when choosing lifestyle:** Percentages of indoor-outdoor cat owners (n=595) reporting different influence strength of factors considered during their decision to choose their cats’ lifestyle, with their major influencing reason. Percentages of consideration given by indoor-only owners who considered an indoor-outdoor lifestyle for their cat (n=131) and the percentage of indoor-only cat owners (n=459) who gave different reasons when asked for the major factor that would cause them to change their cat to an indoor-outdoor lifestyle.

Factors	Strength of Influence on Decision by Indoor-Outdoor Cat Owners (n=595) (%)					Major Reason Lifestyle Was Chosen (n=594) (%)	Strength of Consideration by Indoor-only Cat Owners Who Considered an Indoor-Outdoor Lifestyle (n=131) (%)					Major Reason Indoor-Only Owners Would Switch (n=459) (%)
	None	Weak	Some	Mod.	Strong		None	Weak	Some	Mod.	Strong	
<b>Mental health</b>	1.7	1.2	19.5	6.9	70.8	38	3.1	3.1	16.8	19.8	57.3	35.3
<b>Physical health</b>	1.3	2.7	19.7	7.7	68.6	18	3.8	1.5	16.8	26.7	51.1	16.1
<b>Toilets outside</b>	23.9	12.6	14	17.3	32.3	5.4	42	16	14.5	10.7	16.8	5
<b>Pest control</b>	66.9	17.3	3.2	6.1	6.6	0.5	72.5	9.9	10.7	4.6	2.3	2.6
<b>Cat wants outdoor access</b>	5.6	3.7	13.5	8.6	68.7	32.9	19.1	13.7	22.9	18.3	26	24.4
<b>Other</b>	-	-	-	-	-	5.2	85.5	1.5	3.1	3.1	6.9	16.6

**Table 14, Reasons indoor-outdoor owners would switch to indoor-only:** Indoor-outdoor owners who considered an indoor-only lifestyle for their cat (n=174) and the reported level of consideration given to different factors when making their decision and the percentage of indoor-outdoor cat owners (n=593) who gave different reasons when asked for major factors that would cause them to change their cat to an indoor-only lifestyle would be.

Factors	Strength of Consideration by Indoor-Outdoor Cat Owners Who Considered an Indoor-Only Lifestyle (n=174) (%)					Major Reason Indoor-Outdoor Owners Would Switch Lifestyle (n=593) (%)
	None	Weak	Some	Mod.	Strong	
Prevent hunting	22.4	25.3	18.4	15.5	18.4	5.4
Protect from people	11.5	10.3	19.5	19	39.7	6.9
Protect from traffic	3.4	2.3	5.7	14.4	74.1	45.8
Protect from other cats	14.9	19.5	25.3	28.2	12.1	2.7
Protect from wildlife	32.2	28.7	19.5	10.3	9.2	0.5
Cat has health issues	75.3	8	6.3	2.3	8	34.9
Other	82.2	1.1	5.2	4.0	6.9	3.9

### 3.4. THEMATIC ANALYSIS OF RESPONSES

#### 3.4.1. RATIONALES OF INDOOR-ONLY CAT OWNERS

In addition to the reasons provided within the survey, as detailed in tables 12 and 13, six additional themes were identified from open-text responses. These are as follows: protection from traffic; protection from people; protection from other animals (including wildlife\* and other cats); cat has health issues; to protect wildlife; protection from illness\*; to prevent getting lost\*; acquisition requirement/recommendation\*; personality unsuitable\*; pedigree cat\*; cat has no previous outdoor experience\*. Themes without an asterisk were included within the initial survey, whilst those marked with an asterisk (\*) were identified from open-text responses. Table 9 highlights example quotes from owners used to create these themes. Themes are not mutually exclusive, for example some pedigree cats may be kept as indoor-only as that breed is deemed to be unsuitable for outdoor access, or owners may have been advised by charities to keep FIV+ cats indoors. They do however represent the major, top-level considerations.

**Table 15, Quotes from owners on why they chose an indoor-only lifestyle:** Example quotes from owners used to create the 11 indoor-only rationale themes.

Theme	Example Comments
<b>1) Protection from traffic</b>	'Cats live near a busy road [...] afraid they get killed so keep indoors'; 'Live on [a] main road and [my] previous cat got killed on [the] road'; 'I would consider an indoor-outdoor lifestyle if we had a large garden . . . and we lived away from busy roads'
<b>2) Protection from people</b>	'Previously had cat injured by [a] neighbour'; 'I was advised dog fighting is prevalent in my area and cats are stolen as bait'; 'She is a little blue-eyed cheetah and I worry she would get stolen'
<b>3) Protection from other animals</b>	'We have hawks that live in a large tree in our yard and have seen a coyote in our yard'; 'She gets bullied by other cats'; 'Feral cat colony outside and don't want him exposed to disease'; 'Next door neighbour's Rottweiler killed a cat that went into their garden'
<b>4) Cat has health issues</b>	'Cat is deaf, so cannot safely go outside'; 'Management of IBD'; 'She has had a mammary carcinoma and requires regular medication each day'; 'Cat is FIV+ and needs to be kept inside for his own safety and that of other cats'
<b>5) To protect wildlife</b>	'Domestic cats are a severe threat to birds'; 'Impact of domestic and feral cats on bird and reptile populations'
<b>6) Protection from illness (*)</b>	'To prevent health issues often associated with outdoor animals, such as fleas, ticks, FIV, FIP, etc.'; 'Fleas and ticks live outside. I do not want them in the house!'; 'Outdoor exposure requires more aggressive flea/tick/other parasite treatment'; 'Cat also eats outdoor toxic plants'
<b>7) To prevent getting lost (*)</b>	'Afraid she'd not find her way back'; 'She was lost from her previous owners' house (a few streets away!) for 3 years'; 'Cat runs away to [their] previous house if let out (even after several years)'

<p><b>8) Acquisition requirement/recommendation (*)</b></p>	<p>‘Medical lab cat until 7.5 years old . . . advised to keep indoor as would have no instinct for dangers’; ‘Signed agreement with breeder’; ‘Adoption agency contract specifies indoor-only’</p>
<p><b>9) Personality unsuitable (*)</b></p>	<p>‘She’s also very skittish and I worry about her around traffic’; ‘He is very nervous and easily stressed’; ‘Our cat’s curious but too timid to stay outside for long’; ‘Too timid . . . Shows no interest either’</p>
<p><b>10) Pedigree cat (*)</b></p>	<p>‘Bengals seem notoriously “stupid” when it comes to keeping themselves safe if permitted free reign’; ‘Breed—Devon Rex—specifically bred as indoor cats’; ‘My cat is a breeding queen’</p>
<p><b>11) Cat has no previous outdoor experience (*)</b></p>	<p>‘No outdoor experience when I got him. I don’t think he will have the necessary experience to keep safe’.</p>

*THEME 1, PROTECTION FROM TRAFFIC:* Protection from traffic was the most common consideration influencing owners to keep cats indoors. Primarily, owners focussed on the risk of injury or death. Some owners indicated this fear was due to prior experience. Traffic concerns appeared so strong that an absence of traffic may be enough for some owners to change to an indoor-outdoor lifestyle.

*THEME 2, PROTECTION FROM PEOPLE:* Owners were concerned that people may cause intentional harm to their cat. Comments referenced local incidents or specific neighbours who had displayed such behaviours previously. Theft was an additional concern for pedigree and non-pedigree owners, but for different reasons. Owners of pedigree animals were concerned their animal would be targeted due to their unique appearance and resale or breeding value. Owners of non-pedigree cats mentioned concerns over their cat being taken as bait for dogfighting.

*THEME 3, PROTECTION FROM OTHER ANIMALS:* Concerns regarding interactions with other animals could be divided into those pertaining to cats (both owned and feral), local wildlife \*, and dogs \*. Encounters with other cats were viewed as dangerous due to fighting or disease transmission. Fighting was deemed to have detrimental physical and mental implications. It was of specific concern for those with timid cats who wanted to avoid their cat being ‘bullied’, or of owners with older cats who feared their animal would be unable to defend themselves. Owners with local feral colonies nearby were additionally concerned about these cats being higher risk

disease vectors. More on the concerns of disease transmission is discussed in theme 6. With regards to wildlife, owners feared their cat may become a victim of predation and listed large mammals or birds as potential predators. Snakes were also mentioned specifically, alongside their potential to injure or kill cats and previous bad experiences. Comments pertaining to the potential dangers of dogs predominantly focussed on owned dogs that may attack cats. In some instances, these dogs were known to the owner and were deemed a particular risk.

*THEME 4, CAT HAS HEALTH ISSUES:* Owners felt specific medical issues made it more dangerous for their cat to be outside. FIV was often mentioned explicitly. Some owners gave no further explanation other than to say their cat was FIV+, whilst others detailed their concern for the health of their animal, disease transmission to other cats, or both. Owners were also concerned outdoor access would mean being unable to control medical issues due to being unable to monitor what the cat was ingesting or being unable to give medication when required.

*THEME 5, TO PROTECT WILDLIFE:* Owners viewed an indoor-only lifestyle as an easy way to prevent hunting. This was typically to prevent damage to local bird populations, although some comments additionally mentioned reptiles or small mammals.

*THEME 6, PROTECTION FROM ILLNESS (\*):* Several illnesses were mentioned as potential threats, with many of them such as flu, FIV, or FeLV considered infectious. Owners of cats with ongoing medical conditions had specific concerns about their cats contracting further illness (as discussed in theme 4). Owners highlighted concerns over parasites such as fleas, ticks, or worms, however, in many instances, the focus was not on the welfare of the cat, but rather the owner's discomfort. Owners felt parasites were dirty or unpleasant and something that should not be brought into the home. Owners also acknowledged the inconvenience and expense of the requirement to upkeep preventative treatment of parasites for cats with outdoor access. Additionally, owners highlighted concerns about cats consuming dangerous plants they would not encounter indoors or encountering poisonous substances (e.g., anti-freeze or pesticides) neighbours may use and leave in their gardens.

*THEME 7, PREVENT GETTING LOST (\*):* Owners indicated that their cats were kept indoors to prevent them from getting lost. It was not typically cited if this concern was for their cat's welfare or their own, or if they had attempted to allow their cat outdoors. Some owners suggested they had let their cat out, and the cat returned to a previous home in which they lived. A few owners alternatively used the phrase 'run-away', suggesting they feel their cat may intentionally not return if given the opportunity.

*THEME 8, ACQUISITION REQUIREMENT/RECOMMENDATION (\*):* The opinions of other people were often taken into consideration, particularly those from the place owners had acquired their cat. Adoption centres were frequently cited as influencing owner choice of lifestyle, with some rescue organisations recommending indoor-only lifestyles for specific cats in their care based on their history and temperament. Other rescue organisations appeared to have a blanket policy on all cats being kept indoors. Breeders of pedigree animals also frequently required cats to be indoor-only. Whilst some owners alluded to these being recommendations, in some instances, owners reported both breeders and rescue shelters requiring them to sign a contract committing to keeping their cat indoors.

*THEME 9, UNSUITABLE PERSONALITY (\*):* Some owners felt their cat's temperament made them unsuitable to go outdoors. Some felt their cat's temperament may put them at a greater risk of harm outdoors, such as skittish cats or over-friendly cats. Other owners seemed to feel that the experience of being outdoors would be detrimental to the cat's mental welfare, especially owners of cats who intensely disliked other cats or cats deemed to be timid/shy/anxious. Some owners seemed to indicate they had attempted some form of outdoor access off which they had based their decision, whilst other owners made the decision without trying any form of outdoor access beforehand.

*THEME 10, PEDIGREE CAT (\*):* In addition to the concerns over theft, as presented in theme 2, pedigree cats were often kept indoors as their temperaments were deemed unsuitable to have outdoor access. Numerous breeds were cited as being incapable of looking after themselves outdoors. Other owners believed their cat had no desire or need to go outdoors and has been bred to be indoor-only. A small number of owners felt their breed was unsuitable to go outdoors due to physical attributes, e.g., hairless breeds being unable to keep warm. Less often, owners were using their cats for breeding and aimed to prevent unwanted pregnancy.

*THEME 11, NO PREVIOUS OUTDOOR EXPERIENCE (\*):* Owners of cats who had previously been kept as indoor-only did not want to change that lifestyle to indoor-outdoor. These cats were typically not obtained by their owners when they were kittens. When acquired as adults, owners felt their cats lacked the experience needed to stay safe whilst roaming and so were better off staying indoors.

#### 3.4.2. RATIONALES OF INDOOR-OUTDOOR CAT OWNERS

For indoor-outdoor cat owners, in addition to the five themes provided within the survey questions, five further themes were identified from open-text responses. These were 'beneficial to mental health', 'beneficial to physical health', 'cat indicates they want to go outside', 'cat

toilets outside', 'pest control', 'enrichment\*', 'previous outdoor access\*', 'social opportunity\*', 'safe outdoor space\*', 'multi-cat household\*', and 'natural\*'. Table 16 highlights example quotes from owners used to create these themes.

**Table 16, Quotes from owners on why they chose an indoor-outdoor lifestyle:** Example quotes from owners used to create the 10 indoor-outdoor rationale themes.

<b>Theme</b>	<b>Example Comments</b>
<b>12) Beneficial to mental health</b>	'Would never have an indoor- only cat. Had one some years ago when I lived in a flat and he was a monster. Destroyed furniture, bedding, carpets, and clothing. When I moved to a house, he started to go outside and he calmed down completely'.
<b>13) Beneficial to physical health</b>	'Allows them to . . . control their weight through increased exercise'; 'My cat was kept in for 12 months but had IB symptoms i.e., diarrhoea. I think she was very stressed and unhappy as an indoor cat'.
<b>14) Cat indicates they want to go outside</b>	'I never force my cats either indoor or outdoor but let them make their own decision. This means they have their own choice which helps their mental wellbeing'; 'I don't want my cats to be captive—I want them to be free to choose to stay with us and to live as they choose'.
<b>15) Cat toilets outside</b>	'JLD will not toilet inside and becomes distressed if he has no outdoor access'; 'I hate litter trays!'
<b>16) Pest control</b>	'I rely on their hunting to control rats and mice that would otherwise be attracted to the farmhouse and the chicken pens'.
<b>17) Enrichment (*)</b>	'Her world is so much bigger by having that access to the outdoors'; 'Lots of interaction outside that I cannot provide indoors'; 'My cat has always enjoyed sitting on the grass sniffing the fresh air'; 'I hate the fact that one of my cats hunts . . . However, they both find it distressing to be locked in'
<b>18) Previous outdoor access (*)</b>	'They were five when I got them and they had been used to going out'; 'Most of my eight cats have been stray toms, a couple are still semi-feral, one of which gets very aggressive when kept in all the time'.
<b>19) Social opportunity (*)</b>	'I feel it's unfair to leave my cat at home alone all day, when he could be outside and visiting the neighbours he really likes!'; 'We enjoy having an active cat who engages with other cats in the neighbourhood'.



<b>20) Safe outdoor space (*)</b>	'I also do not live near a busy road so am happier letting them out.'; 'We felt it was best for the cats, so bought appropriate properties'.
<b>21) Multi-cat household (*)</b>	'I live in a small house with four cats. A large garden gives the room to have a break from each other'; 'It seemed unfair to have one rule for one cat and one rule for another'.
<b>22) Natural (*)</b>	'Allows natural behaviour for my cat'; 'I feel that although humans, over the centuries, have domesticated cats, they still very much have a natural desire, interest in . . . the outdoors'.

*THEME 12, BENEFICIAL TO MENTAL HEALTH:* Alongside the thinking that outdoor access was beneficial to mental health, it was felt that confining a cat to the indoors could have negative impacts. Some owners detailed having experienced this with their current or previous cat. The impact of being confined indoors on the cat's mental health was often described as causing stress, depressive states, or states of (sometimes extreme) agitation. Many owners felt that the outdoors did not just prevent negative mood states, but also promoted positive experiences. This is discussed further in theme 17.

*THEME 13, BENEFICIAL TO PHYSICAL HEALTH:* Owners who felt the outdoors was beneficial to physical health recognised that the opportunity for exercise was good for weight management. Owners also mentioned the overlap between physical and mental health. Poor mental health and stress were cited as causing general sickness behaviours, such as vomiting or poor coat condition. Other owners detailed how the stress caused or exacerbated existing conditions, such as cystitis.

*THEME 14, CAT'S CHOICE:* Many owners simply let their cat decide whether they wanted outdoor access. Autonomy and choice were recognised as mentally beneficial for cats in addition to the outdoor access itself. This was so important to some people that they allowed outdoor access even if they would have preferred otherwise. Not giving cats a choice was often deemed as cruel or unfair. Additionally, some owners seemed to appreciate the fact that their cat lived with them through choice because they had the opportunity to leave yet did not take it.

*THEME 15, CAT TOILETS OUTSIDE:* Mentions of toileting habits were predominantly from the perspective of the cats who preferred to do so outside rather than using the litter tray, or in some instances, would only toilet outside. Some owners did, however, mention they preferred their cat to toilet outside.

*THEME 16, PEST CONTROL THROUGH HUNTING:* Whilst many owners kept cats indoors to prevent hunting, as discussed in theme 5, some owners found this trait to have positive utility in terms of pest control. Hunting as a form of enrichment was also identified as beneficial and is discussed more in theme 17.

*THEME 17, ENRICHMENT (\*):* Owners often felt the outdoors provided good enrichment for their cat to keep them entertained and stimulated. Some people detailed that they had purposefully added objects into the garden to accentuate this further. Often, it was felt that this outdoor enrichment was unique and could not be readily replicated indoors, specifically with regards to weather. Sunshine was viewed as a positive experience for many cats who appeared to actively enjoy spending time in it. Fresh air was mentioned as being enjoyable from a cat's perspective, but owners also indicated they felt it beneficial. Cats were detailed as avoiding less favourable weather, such as rain or cold temperatures, but this was usually a choice that the cat was free to make.

*SUB-THEME OF THEME 17, OPPORTUNITY TO HUNT:* The opportunity to hunt was often viewed as a natural and instinctive behaviour which could readily be provided for outdoors should the cat wish. Owners did not necessarily encourage this behaviour but accepted it as beneficial to the cat's wellbeing for them to have the opportunity. Some owners had aversions to hunting but appeared to feel their cats' wellbeing outweighed this.

*THEME 18, PREVIOUS OUTDOOR ACCESS (\*):* Many owners obtained adult cats with previous outdoor experience and so felt they did not want to deprive them of the outdoor access they had been used to. Cats who were strays, feral, or farm cats were specifically mentioned as these cats were used to spending large portions of their time outdoors. Some owners alluded to keeping these cats indoors temporarily to detrimental effect.

*THEME 19, SOCIAL OPPORTUNITY (\*):* The opportunity for social interaction with people and conspecifics outside of the immediate household was recognised as beneficial. Cats were detailed as enjoying interacting with neighbours, and owners appreciated how this brings happiness to the neighbours in turn. It was also felt to be unfair to not allow cats to have the opportunity to socialise when the owners were not at home. Cats were also reported to spend time interacting positively with other cats in the neighbourhood.

*THEME 20, SAFE OUTDOOR SPACE (\*):* The dangers cited by the owners of indoor-only cats, such as traffic or wildlife, were also acknowledged by the owners of indoor-outdoor cats, yet many owners felt the area they lived in was safe enough to mitigate the risks of injury or death

sufficiently. For those who felt their area was safe enough to allow their cat outside, it was unclear what they would do should they have to move, with some owners acknowledging they might reconsider providing outdoor access in such circumstances. However, some owners felt the outdoors was of such benefit to their cat that they ensured their property was safe enough to allow outdoor access when they were looking for a home.

*THEME 21, MULTI-CAT HOUSEHOLD (\*):* The management of cats within a multi-cat household was deemed to be easier by allowing outdoor access. Many cats lived in multi-cat households where the lifestyle of previously obtained cats determined the focal cat's subsequent lifestyle. In instances where the focal cat had joined a household which already contained cats with outdoor access, owners felt that unequal treatment was unfair and that the cats themselves may feel so too. Additionally, the extra space provided outdoors was cited to be beneficial for allowing cohabiting cats to have time away from one another. It was felt that outdoor space reduced the amount of physical conflict and aggression between cats of the same household.

*THEME 22, NATURALNESS (\*):* The term 'natural' was frequently used in explaining why outdoor access had been chosen. This was seen to encompass many of the previously discussed themes around mental and physical benefits, enrichment such as climbing and exploring, as well as the need to hunt. The unique domestication of cats and fluidity of individual cats' socialisation was also mentioned to highlight the 'nature' of cats and as a reason to allow outdoor access.

#### 4. DISCUSSION

Overall, 41% of cats within this study were indoor-only. Differences were seen among the three global regions—at 30.2% in Europe, 80.6% in the USA and Canada, and 42.2% in AUS and NZ. Region was found to have a significant impact on lifestyle, with cats comparatively much less likely to be indoor-outdoor in the USA and Canada (OR 0.093) and AUS and NZ (OR 0.510) than in Europe. The proportions of cats kept indoors in Europe in this study were not too dissimilar to others. In the UK, 26.1% of cats were indoor-only (Finka et al., 2019); in Denmark, 16.8% of cats were indoor-only; (Sandøe et al., 2017) and in France, 34% were indoor-only (Roussel et al., 2019). For the USA and Canada, results in this study showed a higher percentage of indoor-only cats compared to a reported 63% (Strickler & Shull, 2014) and 60% (Grigg & Kogan, 2019) for the USA, or 56% in Canada (Canadian Federation of Humane Societies, 2017). For AUS and NZ, it has been reported that 44% (Kendall & Ley, 2006) or 46.5% (Elliott et al., 2019) of cats in Australia are indoor-only, whilst in Melbourne specifically, it was reported to be 23% (Jongman, 2007). In New Zealand, it has been reported that 10.7% of cats were indoor-only at all times (Harrod et al., 2016), whilst 26% were indoors during the night (Linklater et al., 2019). Although our study

broadly concurs with others there are notable differences in proportions of indoor cats within specific regions. It is likely that intra-region variation amongst studies arises due to the grouping of regions in this study, where previous studies typically focus on a single country or state within a country. It is also possible that recruitment methods and advertised study aims influenced the demographics of respondents replying to each study.

#### *SAFETY*

Safety, in some regards, was the primary motivating factor for keeping cats indoors across all three regions (USA and Canada, 84.3%; Europe, 88.2%; and Australia and New Zealand, 53.7%). The motivation for owners wanting to keep their cat safe seemed to be both a concern for the welfare of their cat and protecting themselves from the emotional harm of losing their cat to fatal incidents. Safety concerns have been acknowledged in other studies. A UK study found 63% of UK owners with indoor cats felt it was unsafe for their cat to be outdoors (PDSA, 2016). An Australian study found 75.4% of cat owners felt keeping cats contained was important to protect them from injury (Toukhsati et al., 2012). Whilst a New Zealand study found 45% of people who kept their cats indoors at night did so due to safety (MacDonald et al., 2015). These differences in numbers may arise due to variations in the owner populations being studied. Both the Australian and New Zealand studies included owners who allow their cats to roam in some capacity and such owners are perhaps less likely to be concerned over safety than the owners of indoor-only cats.

#### *ROAD-TRAFFIC ACCIDENTS*

The greatest influencing factor for an indoor-only lifestyle, which was consistent across global regions, was protection from RTAs. Concerns over RTAs have been indicated elsewhere. Of UK indoor-only cat owners who deemed the outdoors to be unsafe, 83% felt this way due to traffic concerns (PDSA, 2016). However, incidences of RTAs, in the UK at least, appear relatively low. Whilst fatal RTAs are difficult to quantify because they are typically not reported, and record keeping by local authorities and veterinary practices vary, several UK studies have aimed to estimate these figures. One study found only 4.2% of cats registered to VetCompass and presented to the emergency, out-of-hours practices in the UK between January 2012 and February 2014 had been involved in an RTA (Conroy et al., 2019). In Cambridgeshire, UK, an estimated 12% of cats had survived an RTA (Rochlitz, 2003). With these veterinary studies, it must be considered that RTA numbers are likely to be higher because deceased animals are not likely to be presented to practices. A longitudinal cohort study of 1264 UK cats negated this bias of not reporting fatal incidents and found that, within the first year of life, 3.9% of cats were found to be involved in RTAs, with 71.4% of these being fatal (Wilson et al., 2017). These UK-

based figures are unlikely to be applicable to other countries, or even regions within the UK different from the studied area, due to differing densities of free-roaming cats, varying levels of traffic, or traffic speed. Consequently, more research into the RTA rates in different regions is required to help owners better understand the risks of providing an indoor-outdoor lifestyle.

Despite these overall low incidence rates, many previous studies have identified RTAs to be a major, or leading, cause of accidental death for younger pet cats specifically (McDonald et al., 2017; Murray et al., 2017; O'Neill et al., 2015; Rochlitz, 2003). The increased risk for younger cats is likely due to a combination of factors such as a lack of experience and higher energy levels, resulting in a greater propensity to roam (McDonald et al., 2017). It has also been found that older cats are less likely to engage in risk-taking behaviours, including crossing roads (Loyd et al., 2013). Results from this study suggest owners may recognise that potentially risky behaviours may be more common in junior cats because this age group had greater odds of being kept as indoor-only cats compared to adult cats. Given the energy levels of, and stimulation required for younger cats, it is therefore particularly important that sufficient enrichment is provided within the home. In contrast, senior cats were the most likely age group to be provided with outdoor access. In free-text responses, older cats were detailed as only utilising garden spaces rather than roaming freely. For example, 'Eldest [cat] is 11 years [old] and goes out unsupervised twice a day but remains in the garden' and 'Now he [cat] is older he never leaves my garden'. For older cats with previous experience outdoors particularly, it is promising that the recognition of this lower-risk outdoor behaviour may alleviate owner safety concerns over RTAs and make them more amenable to providing outdoor access.

#### *URBANISATION*

It is known that the number of indoor-only cats is rising, and it has been theorised that this may, in part, be due to increasing urbanisation. This theory is supported by the findings of this study, which indicated city or urban-dwelling owners and those living in flats or apartments are significantly more likely to have an indoor-only cat. Alongside owners not having outdoor space available, increased traffic in these urbanised areas is likely to be a contributing factor to the number of indoor-only cats, given the high level of safety concerns reported. Despite RTA fears in urban areas, and some indoor-outdoor owners only allowing outdoor access for their cat because they felt they lived in an appropriately quiet area with an absence of traffic (theme 20), the concerns over increased RTAs within built-up areas may be unfounded. One study found no significant association between area (urban/rural) and higher RTA mortality (McDonald et al., 2017). Whilst a second did find differences in RTA prevalence between areas, it was cats living in rural areas that seemed to be at increased risk when compared to cats within urban

environments (Wilson et al., 2017). More detailed insights as to how, where, or when RTAs occur, including the time of day, could mean that owners in lower-risk areas are able to make more on-balance decisions, comparing the risks of outdoor access and any individual needs of their cat.

#### 4.1. VARIATION BETWEEN REGIONS

The second most cited reason for keeping cats indoor-only varied throughout the three regions. In the USA and Canada, it was for protection from wildlife (19.9%). In Europe, it was protection from people (18.1%). In Australia and New Zealand, it was to prevent cats from hunting (29.6%). This difference between regions could be due to variation in geography, urbanisation, and local wildlife. Respondents from Europe were predominantly UK-based (80.3%). The UK is densely populated and highly urbanised when compared to many regions within the USA, Canada, Australia, and New Zealand, which all have large, sparsely populated areas. Therefore, it is reasonable that owners in Europe have urban-centric concerns, whilst in the USA, Canada, Australia, and New Zealand, concerns are typically nature-orientated. The differences in concern for wildlife in the USA, Canada, Australia, and New Zealand may be explained by the types of wildlife found between the regions, as well as whether predators are endemic or not.

In the USA and Canada, large predators are commonplace. The presence of larger predators such as coyotes, eagles, or bears may mean prey species have adapted better to avoid predation, dampening the effects of depredation by cats and meaning cats are at risk of predation themselves. In Australia and New Zealand, there are no large predators, although poisonous insects or snakes may still pose a risk to cats. The absence of predators makes local wildlife particularly susceptible to cat depredation, and this ecological niche has made it easy for cats to reproduce and survive. Consequently, in Australia and New Zealand, there are large feral populations which have been estimated as being more numerous than owned cat populations (Legge et al., 2017), and cats are classed as an invasive species (Australian Government, 2015). Many studies in Australia and New Zealand have investigated the attitudes of both cat owners and non-owners towards wildlife depredation and have repeatedly found it is a concern for both (Hall et al., 2016; Toukhsati et al., 2012; Woolley & Hartley, 2019). The management of cats has previously been found to reflect this concern, with many owners in these regions restricting outdoor access entirely or at certain times of the day (Linklater et al., 2019; Toukhsati et al., 2012), echoing the findings of this study.

## 4.2. PEDIGREE

Pedigree cats were more likely to be kept indoors than non-pedigree cats. Pedigree animals were described as ‘stupid’, ‘dopey’, or lacking ‘common sense’, and owners stated they were ‘not designed for the outdoors’ or had been bred to be indoor-only. Despite these concerns, the authors of this paper find no evidence to suggest different breeds may be suited to an indoor-only or indoor-outdoor lifestyle. It is possible that specific conformations could limit the ability of some pedigree breeds to survive outdoors. For example, brachycephalic breeds, such as Persians or Exotics, may suffer from respiratory issues (Farnworth et al., 2016) and struggle to eat or chew due to shortened muzzle lengths and dental abnormalities (O’Neill et al., 2019), which could impair activity levels and hunting behaviours. Hairless breeds, such as Sphynx cats, may struggle to regulate their temperature in colder climates. Whilst these phenotypic variations may reduce life-expectancy in unowned cats, it is not known if they would substantially impact behaviour or welfare in cats provided with shelter, food, and veterinary care, who also have outdoor access. Indeed, it has been tentatively found that pedigree cats are less likely to be in RTAs than non-pedigree cats, although sample sizes within the study were small (Rochlitz, 2003). It was posited this could be due to more time-restricted outdoor access of pedigree cats, or that owners may spend more close contact time with pedigree animals than non-pedigree, which may in turn impact their behaviour outdoors. As evidence is emerging that behaviour may vary between breeds, in terms of social behaviour, activity levels, and temperament (Duffy et al., 2017; Marchei et al., 2011; Salonen et al., 2019; Takeuchi & Mori, 2009; Wilhelmy et al., 2016), it is reasonable to assume that variation in temperament may impact suitability for different living conditions. Further research into how breed-specific differences influence welfare across different lifestyles is therefore warranted.

## 4.3. MENTAL WELLBEING

Both indoor-only and indoor-outdoor owners felt outdoor access was beneficial to mental wellbeing, seemingly as it readily allows for the expression of natural behaviours. Outdoor-specific enrichment included weather (theme 17), hunting opportunities (theme 17), toileting preferences (theme 15), and socialisation with other cats and people (theme 19). Some owners detailed how they provided additional enrichment for their cats in their outdoor spaces. At present, no research has been conducted on the quality of outdoor environments cats have access to and their implications for cat welfare. It is possible that welfare differences may arise between cats with outdoor access living in rural environments with few other domestic cats, large open areas, and abundant wildlife such as bird and rodents compared to cats living in urban

environments with dense cat populations and those with either basic or enriched outdoor spaces provided by their owners.

#### 4.4. PHYSICAL HEALTH

Potential benefits to the physical health of outdoor access were strongly recognised by both indoor-outdoor and indoor-only owners. Comments alluded to the opportunity for exercise, and how obesity might be mitigated through outdoor access if it increases overall activity levels in indoor-outdoor cats compared to their indoor-only counterparts. These owner views are consistent with literature that suggests an indoor-only lifestyle is a risk factor for feline obesity (Buffington, 2008; Rowe et al., 2015). Obesity was recently cited by UK vets as the major health concern for owned pet cats (British Veterinary Association, 2016), with obese animals being more likely to suffer from additional ailments such as arthritis or diabetes (Laflamme, 2012). More research into the activity levels of indoor-only versus indoor-outdoor cats, or the exercise opportunities of indoor-only cats, could help with management strategies to ensure healthy weights and could be a cheap, easy, and non-invasive way for owners to improve their cat's welfare.

A growing body of literature also suggests that stress-related illnesses, such as lower urinary tract signs, are typically more prevalent in indoor-only cats (Longstaff et al., 2017; Turner & Bateson, 2000). Although anecdotal, some owners did appear to notice improvements in their cat's physical health when cats were given outdoor access after a previous restriction, and this was sometimes linked to improvements in mental health (theme 13). It might therefore be that affording outdoor access to cats with some pre-existing conditions could help to alleviate them. Despite this, pre-existing health conditions were found to be a significant predictor for cats being kept indoor-only. Whilst the frequency of specific pre-existing health conditions was not quantified, it is possible that many cats were FIV+ and FeLV+, as alluded to in theme 4 and 6, where responsible management has typically included the restriction of outdoor access to these cats.

#### 4.5. CAT AUTONOMY

Most indoor-outdoor owners (94.4%) took into consideration that their cat indicated they wanted outdoor access when deciding on lifestyle. It was the major reason for providing this lifestyle for around a third of owners. Similarly, an Australian study found that 37% of owners who allowed their cat outdoor access at night did so for the cat's freedom (MacDonald et al., 2015). In comparison, 80.9% of indoor-only owners who considered an indoor-outdoor lifestyle considered if their cat indicated they wanted outdoor access. However, only 8.2% of indoor-only



cats were ultimately reported to 'choose' their lifestyle by not leaving the house when able to. This leaves an overwhelming majority of 91.8% of indoor-only cats who may otherwise opt to roam outdoors if given the opportunity.

From this small percentage of cats opting not to go outside when given the choice, one may infer that most cats are highly motivated to access outdoor spaces if available. Some owners did report negative behavioural differences in their cats when restricting their outdoor access (themes 12 and 21), and indeed, undesirable behaviours are commonly reported as being more prevalent in indoor-only cats when compared to those with outdoor access (Amat et al., 2009; Finka et al., 2019; Heidenberger, 1997; Sandøe et al., 2017; Schubnel & Arpaillange, 2008). Whilst enrichment items may provide the opportunity for cats to express natural behaviours indoors, the observed levels of undesirable behaviours in indoor-only cats might generally indicate the provision of suboptimal environments. As found in the systematic review in chapter 1, numerous gaps in the literature exist with regards to indoor-only cat welfare. It also noted that some enrichment guidelines recommended by behaviourists or charities may not be evidence-based. This dearth of literature in the area may make it more difficult for owners to fully meet their cat's behavioural needs within the home.

Currently, it is not known how the prevalence of undesirable behaviours, stress-related illnesses, or other welfare indicators vary between cats who choose to stay indoors, and those who have the choice made for them. It may be cats without the opportunity of choice are of an increased welfare concern. It has been posited that environmental control is beneficial for animals (Broom & Johnson, 1993), and recent research into other domestic or captive species, including great apes, pandas, sheep, and goats, has demonstrated the positive impact of choice and control on welfare (Anderson et al., 2002; Kurtycz et al., 2014; Owen et al., 2005). Further research into how choice and control may impact welfare in cats with owner-controlled and time-restricted outdoor access, as opposed to a freely accessible cat-flap, is therefore warranted.

#### 4.6. ALTERNATIVE LIFESTYLE

Most respondents did not consider an alternative lifestyle for their cat. This might suggest owners have an inherent view of appropriate cat husbandry they do not deter from. Such views are of potential concern if owners do not consider how individual temperaments or life experiences are suited to different lifestyles. However, it may transpire that owners did not consider an alternative lifestyle as they chose a cat deemed suitable for the lifestyle they wanted to provide. Further study into whether owners seek a suitable cat for their preferred lifestyle could indicate whether cats may be suffering due to inappropriate husbandry.

In this study, there was some indication owners may select a cat suitable for their chosen lifestyle. Some owners felt their cat's personality was unsuitable for outdoor access (theme 9), indicating that they were making a judgement of their cats' temperament and providing for them as they saw best. Other owners maintained the lifestyle their cat was used to, whether that be indoor-only or indoor-outdoor (themes 11 and 18). Additionally, owners indicated they were acting upon advice from veterinary professionals or rescue centres from which the cat was acquired (theme 8), although it is not evident whether this advice was based on temperament and lifestyle suitability or other factors such as safety or cat depredation.

When owners reported the major reason they would change their cat's lifestyle, results echoed those of owners who had chosen the opposite lifestyle. For example, most indoor-only owners chose this lifestyle to protect their cat from traffic (58.7%), and most owners of indoor-outdoor cats reported if they were to change their cat's lifestyle to indoor-only, it would be due to traffic (45.8%). Conversely, the benefits of outdoor access to mental health were acknowledged by many indoor-outdoor and indoor-only owners, with 38% and 35.3% giving this as the major reason for the lifestyle choice, or the reason they would change, respectively. This might suggest owners do recognise the positive and negative factors attributed to each lifestyle, even if they have a preferred lifestyle they adhere to.

Currently, we are unsure if there are differences between the management of indoor-only and indoor-outdoor cats with regards to resource provision, enrichment, and social interaction. If management varies, this could account for some of the perceived differences in the need for cats to obtain enrichment outdoors. For example, indoor-only cat owners who recognise the potential mental benefits of outdoor access may be more inclined to provide additional enrichment within the home when compared to those who do not acknowledge that outdoor access can be beneficial. Conversely, indoor-outdoor owners may feel that outdoor access is sufficiently enriching and provide less within the home, which could be problematic if they provide restricted outdoor access.

## 5. LIMITATIONS

As with any research, methodological limitations must be acknowledged. Online convenience sampling is a practical way of contacting large numbers of international cat owners; however, it may introduce sample bias. Owners chancing upon, and opting into, a survey regarding their cat may be systematically different from owners who do not find or engage in such surveys. This may be true for those who consent to participate in further studies and those who did or did not respond to the second survey. Generally, owners who did not participate may feel less strongly

about the topic than owners who freely opted to give spare time for completing the surveys. This should be remembered when contemplating the strength of consideration owners assigned to different factors that influenced their decision making.

Additionally, it is acknowledged that this study does not present an exhaustive list of factors which may influence owner decision making. Other influences may include, but not limited to, previous cat ownership, place of cat acquisition, and age of cat at acquisition, as suggested by the thematic analysis. Unfortunately, this data was not gathered within the initial survey, and so these variables could not be included within the odds ratio analysis to assess whether they may have a significant association with specific lifestyles. As this study was the first detailed look at owner rationale for cat lifestyle, it is hoped that further studies can expand upon the results presented in this paper.

## 6. CONCLUSIONS

Ten owner and cat demographic variables were significantly associated with greater odds of cats being provided with either an indoor-only or indoor-outdoor lifestyle, inclusive of the global region, owner age, or cats having health issues, etc. Many of these variables offer evidence that urbanisation could be a driving factor behind the current data trends which suggest owners globally are moving towards indoor-only lifestyles for their cats. It was shown that owners living in city centres, urban environments, and flats/apartments were significantly more likely to have indoor-only cats. Strong concerns over traffic were voiced by indoor-only and indoor-outdoor cat owners, and RTAs were a major influencing factor for owners when deciding on lifestyle. Because urbanisation is set to continue, it is reasonable to assume that the proportion of indoor-only cats will continue to rise.

Considering the anticipated increase in indoor-only cats, alongside current literature suggesting indoor-only animals may exhibit more 'undesirable' and stress-linked sickness behaviours than indoor-outdoor cats, research focussing on how best to improve the behaviour and wellbeing of indoor-only cats would be beneficial. Particular attention should be paid to subgroups of cats found to be significantly more likely to be kept indoor-only, such as pedigree animals. Despite certain pedigree breeds being perceived as being better adapted to an indoor-only lifestyle, there is currently a paucity of scientific evidence in this area.

Finally, owners appeared to hold an inherent position in which they believe cats should have an indoor-only or indoor-outdoor lifestyle, as indicated by most owners not actively considering the alternative lifestyle. It is important for owners to recognise the individual needs of cats with

different temperaments, activity requirements, or previous life experiences, lest the welfare of individuals suffer if not adequately provided for.

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# CHAPTER FOUR: ASSOCIATIONS BETWEEN CAT LIFESTYLE, BEHAVIOUR, OWNER MANAGEMENT AND ENVIRONMENT

## 1. INTRODUCTION

Domestic cats (*Felis catus*) are globally popular companion animals, with estimates suggesting there are approximately 94.2 million owned domestic cats in the USA (APPA, 2018) and 10.9 million in the UK (PDSA, 2020). How best to care for these cats is important to owners, charities, veterinarians and animal researchers alike. Currently, whether cats should be provided with outdoor access is a particularly contentious issue. Outdoor access has long been considered beneficial to domestic cat wellbeing. It offers opportunities to exercise and facilitates natural behaviours such as exploring, hunting, patrolling and marking territories. It also provides substantial daily variations in sights, sounds and smells that are unlikely in a home setting. However, the outdoors also carries risks for cats such as traffic, wild animals and people who may wish to cause them harm. Such dangers are unique to the outdoor environment and, alongside concerns of wildlife depredation, are known to be sources of anxiety to owners (Foreman-Worsley et al., 2021; Tan et al., 2020). Consequently, an increasing number of owners are opting to keep their cats indoors. Whilst an indoor lifestyle may protect cats from some dangers and relieve owner anxiety, there are concerns over the impact of an indoor-only lifestyle on their physical and mental wellbeing. Indoor-only cats have higher levels of obesity than those with outdoor access (Buffington, 2002; Rowe et al., 2015; Wall et al., 2019), may be restricted in their ability to carry out natural behaviours and may have less opportunity to escape undesirable interactions with other household cats, humans or dogs. Expert and organisational guidelines regarding outdoor access lack consensus but are largely cultural, with owners and charities within the USA predominantly favouring an indoor-only lifestyle, whilst the UK and Europe favour outdoor access (Foreman-Worsley et al., 2021; Sandøe et al., 2017).

To understand how the environment may influence cats' affective states, behavioural indicators are often used as a measure of welfare. Sickness behaviours such as vomiting, diarrhoea and overgrooming may be indicative of the presence of environmental stressors and poor cat welfare (Stella et al., 2013), whilst behaviours such as house soiling, excessive vocalisation or furniture destruction may be indicative of inappropriate owner care practices (Bradshaw, 2018). Undesirable behaviours are not necessarily indicative of poor welfare, however their undesirability for owners means they may still be of concern. For ease, throughout this chapter these types of behaviours will be referred to as 'problem behaviours' with the understanding that they are usually problematic for owners, whilst often being natural for the cat (e.g. scratching furniture). It is well reported that problem behaviours can have negative consequences for cats, as owners may resort to abandonment, punishment (Moesta et al., 2017), declawing (Yeon et al., 2001), or relinquishment of the cat to rehoming charities (Casey

et al., 2009; Coe et al., 2014; Jensen et al., 2020). Unfortunately, problem behaviours are seemingly commonplace in owned cats. Grigg et al. (2019) found 97.8% of owners reported their cat displays at least one problem behaviour. Additional studies have shown between 61% (Strickler & Shull, 2014) to 77% (PDSA, 2020) of owner's desire to change one or more of their cat's behaviours. To reduce problem behaviours, it is important to understand which factors within the management of the cat and the home may contribute to their expression.

Cat lifestyle (e.g. indoor-only, indoor-outdoor) is a factor frequently implicated in the prevalence of problem behaviours. However, current findings are not wholly conclusive as to the direction of effect that lifestyle has on such behaviours. Whilst the majority of studies have generally found that problem behaviours are more prolific in cats kept as indoor-only (Amat et al., 2009; Barcelos et al., 2018; de Souza Machado et al., 2020b; Finka et al., 2019; Heidenberger, 1997; Sandøe et al., 2017; Schubnel & Arpaillange, 2008; Tamimi et al., 2015), several recent studies have suggested a higher prevalence of problem behaviours in cats with outdoor access (de Souza Machado et al., 2020b; Grigg & Kogan, 2019; Strickler & Shull, 2014). As reported in Chapter 2, with regards to how multi-cat households may impact wellbeing, differences in the direction of effect that lifestyle has on problem behaviours may be caused by differences in methods and reporting between studies. For example, indoor spraying and marking behaviours are those typically cited as being more prevalent in cats with outdoor access (Barcelos et al., 2018; de Souza Machado et al., 2020b; Tamimi et al., 2015), whilst overall levels of problem behaviours appear to be higher in cats that are indoor-only (Amat et al., 2009; de Souza Machado et al., 2020b; Finka et al., 2019; Sandøe et al., 2017). Studies that selectively measure certain behaviours, or studies with weighting towards indoor-only or indoor-outdoor cats, may reveal relationships between lifestyle and behaviour that would not be present in larger, more balanced sample sizes, or when looking at a wider range of problem behaviours. Differences may also occur due to nuances between lifestyle classification. For example, amongst studies, or within a single study, 'outdoor access' may reflect vastly different managements in practice. On one end of the scale, outdoor access may refer to a cat with the opportunity to access the outdoors at will (e.g. through a cat flap), with freedom to roam once outside (hereafter an 'unrestricted indoor-outdoor' lifestyle). Conversely, indoor-outdoor may represent a cat able to access the outdoors for short durations when decided by an owner and restricted to enclosed areas such as the garden, or even catios (enclosed rooms designed specifically to provide enrichment for cats, typically with mesh or net walls to allow some access to the elements) (hereafter a 'managed indoor-outdoor' lifestyle). Such large variation may have a substantial impact on a cat's relative experience, by reducing the level of freedom outdoor access can

provide or restricting many of the enrichment opportunities thought to be beneficial whilst outdoors. These differences may have an impact on problem behaviours in turn, and so how indoor-outdoor cats are grouped should be an important consideration during study design.

The number of indoor-only cats has risen in recent years, and this is likely to continue due to further urbanisation (Foreman-Worsley et al., 2021). Thus, understanding the impact of lifestyle on behaviour and how different lifestyles contribute to problem behaviours is important for mitigation. Emerging literature suggest there are differences between the management of indoor-only and indoor-outdoor cats (Clancy et al., 2003; Foreman-Worsley et al., 2021; Lawson et al., 2019; Tan et al., 2021). For example, both Foreman-Worsley et al. (2021) and Tan et al. (2021) found that female cats, those with medical issues, juvenile cats and pedigree cats were significantly more likely to be kept as indoor-only cats. With regards to environment and provisions, de Souza Machado et al. (2020b) found indoor cat owners were more likely to provide litter trays and frequently buy their cat gifts and toys, when compared to outdoor cat owners (inclusive of exclusively outdoor/or working farm cats, who may receive different caretaking to indoor-outdoor cats). Tan et al. (2021) found that cats with indoor-only lifestyles were more often provided with enrichment items such as toys, litter trays, scratching posts and puzzle feeders. Overall, there is a paucity of research in the area, and it is currently unknown if these factors play a role in the different levels of problem behaviours seen between cats of different lifestyles.

Current literature suggests that cat, owner and environmental features such as neuter status (Adamelli et al., 2005; Amat et al., 2009; Grigg & Kogan, 2019; Heidenberger, 1997; Sandøe et al., 2017), time spent interacting with owners (Heidenberger, 1997; Tamimi et al., 2015), declaw status (Grigg & Kogan, 2019) and toys provided (Kogan & Grigg, 2021; Strickler & Shull, 2014), amongst other variables, have significant impacts on reported problem behaviours in cats within the domestic home. However, a comprehensive review of available literature (table 17) showed that, as for lifestyle, the direction of effect these variables have on the prevalence of problem behaviours is often inconclusive. Similarly, differences likely arise through methodological variation amongst papers, e.g. variation in the specific behaviours measured, the number of behaviours measured, differing or unclear use of statistical analysis, or single behaviours being analysed against many environmental variables, which may subsequently increase the rate of type-1 errors. Additionally, multiple testing of variables across a range of individual behaviours means variables within a single paper may appear to both increase and decrease problem behaviours. For example, Yamada et al. (2020) found older cats had both increased and decreased problem behaviours, depending on the specific behaviour being tested. A recent

systematic review exploring wellbeing in multi-cat homes found similar inconsistencies in results across the literature, likely due to similar methodological variation (Finka & Foreman-Worsley, 2021: Chapter 2). It is therefore important to put significant consideration into the methodology when it comes to testing environmental variables and problem behaviours, ensuring the output answers specific pre-defined questions to prevent confusion between intra-study results.

This chapter will aim to assess the extent to which the environments of indoor-only and indoor-outdoor cats differ. Similarly, it will investigate if owner-reported problem behaviours are significantly different between cats of different lifestyles. Finally, it will explore whether environmental differences could help to explain any observed variations between the levels of problem behaviours amongst cats of different lifestyles. Given the current contradiction between the impact of different variables, inclusive of lifestyle, on the prevalence of owner-reported problem behaviours, a composite approach will be utilised to provide a top-level overview of how different dimensions of a cat's environment play a role in influencing these reported behaviours.

This will be achieved by investigating:

- If owner-reported levels of problem behaviours vary with indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor lifestyles
- If significant differences between the management and environment of cats with indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor lifestyles are evident, with regards to social aspects and physical provisions
- Whether different variables contribute towards the levels of owner-reported problem behaviours across cats with indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor lifestyles

## 2. METHODS

### 2.1. SURVEY CREATION AND DISTRIBUTION

An online survey was created using Jisc Online Surveys, as detailed in chapter 3. The survey was split into three parts, with responses from sections of part one being the utilised within this study (see appendix A3). The survey was distributed in English to current cat owners through social media, predominantly Facebook and Twitter, between February 2019 and April 2019, after an initial piloting stage tested on friends, family and colleagues. There were no geographical restrictions on participants, however, participants were excluded if the cat lived exclusively outdoors or if the owner was under the age of 18. Questions utilised within this study



explored owner demographics, cat demographics, cat health, problem behaviours, cat lifestyle, home environment details including basic provisions and enrichment, and the presence of adults, children, cats and dogs within the household. Questions consisted of multiple and single choice questions and Likert scales. Ethical approval was granted on the 11th December 2018 by Nottingham Trent University School of Animal, Rural and Environmental Sciences Research and Ethics Committee (ARE843).

## 2.2. DATA PROCESSING

### 2.2.1. EXCLUSIONS

After cleaning, 5048 usable responses were obtained for this study. Responses from multi-cat households were limited to households of 5 or fewer cats (n=214 removed), instances where the total number of adults within the household exceeded 7 were excluded (n=4) and instances where 6 or more dogs were present were excluded (n=6). Data exploration through histograms indicated these responses were outliers and likely do not reflect typical cat-owning households. It was considered that the behaviour of cats within this environment might be altered based on the intensity of the social environment (see chapter 2), and so their exclusion may help to ensure results were generalisable to typical households with cats. Owners who indicated they were currently transitioning their cat from one lifestyle to another (e.g. indoor-only cats incrementally being provided with outdoor-access) were excluded (n=2), as these situations were not deemed to be comparable to stable lifestyles. Responses were also excluded where answers were not logical, e.g. where cats were detailed as having access to 'zero' rooms within the house (n=4), where respondents had detailed that 'zero' adults lived within the house (n=46) and where respondents had detailed it was a multi-cat household but given the total number of cats as 'one' (n=24). It is likely that these illogical responses were the result of respondents misreading or misinterpreting the question despite the survey being piloted before full distribution, e.g. if respondents lived alone and did not count themselves in the total number of adults within the household they may respond with 'zero'. Given the large sample size, the exclusion of these responses was deemed to improve the validity of the study, and did not prevent any statistical analysis being conducted.

Data was checked for unbalanced groups that might affect analysis. The smallest subgroups of cats were those that were unneutered (3.6%, 188/5048), and those that were declawed (2.1%, 107). These subpopulations of cats were excluded from the models as unbalanced groups may negatively impact the validity of result. However, for general reporting of demographics, behaviours, environment and enrichment, where no statistical analysis was taking place, these

cats were retained within the sample as they represent valid subgroups of cats that exist within the owned cat population.

### 2.2.2. LIFESTYLES

Regarding indoor-only or indoor-outdoor lifestyles, to ensure accuracy of analysis, open-ended comments on outdoor access were read in their entirety and responses recoded where necessary (n=69). For example, one respondent indicated their cat was indoor-only, but in the comments detailed 'They have a large outdoor enclosure' and so the response was changed to 'indoor-outdoor', and more specifically, 'enclosed outdoor access'. Comments that indicated a different lifestyle to that which had been entered but were not detailed enough to confidently recode into pre-defined groups were excluded from analysis (n=23).

### 2.3. VARIABLE SELECTION AND COMPOSITE SCORES

To identify biologically meaningful candidate explanatory variables for the models, a semi-systematic search of the literature was conducted. This literature exploration revealed a range of variables reported as having a significant impact on problem behaviours. These variables covered cat features, owner features and aspects of the environment, both physical and social, as seen in table 17. No clear direction of effect was present for several variables e.g. older cats were found to have both a lower prevalence of problem behaviours (Barcelos et al., 2018; Finka et al., 2019; Heidenberger, 1997; Yamada et al., 2020) and a higher prevalence of problem behaviours (Hart et al., 2018; Wilson et al., 2016; Yamada et al., 2020), as discussed within the introduction. Consequently, all variables identified as having a potentially significant impact on problem behaviours were taken forward to be used as explanatory variables, in the form of composite measures where appropriate for the data (see 2.2.4.1. for more detail).

**Table 17, Variables reported to impact problem behaviours as reported in the literature:**

Variables extracted from currently available literature reported as having a significant impact on, or association with, problem behaviours in cats within the domestic home. Variables are reported with the direction of effect as detailed in the original literature. \*(Adamelli et al., 2005) additionally identified age and the number of family members as significant in influencing problem behaviours, however the direction of effect was not specified.

	<b>Variable associated with lower prevalence of problem behaviours</b>	<b>Variable associated with higher prevalence of problem behaviours</b>
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<p><b>Cat features</b> *</p>	<p><b>Age:</b> Adult (Wassink-van der Schot et al., 2016); Mature (Wassink-van der Schot et al., 2016); Senior (Yamada et al., 2020)</p> <p><b>Sex:</b> Females (Strickler &amp; Shull, 2014; Takeuchi &amp; Mori, 2009); Male (Wassink-van der Schot et al., 2016; Yamada et al., 2020)</p> <p><b>Pedigree:</b> (Ramos &amp; Mills, 2009; Salonen et al., 2019; Sandøe et al., 2017; Takeuchi &amp; Mori, 2009; Tamimi et al., 2015; Yamada et al., 2020)</p> <p><b>Early neutering:</b> (Paz et al., 2017)</p>	<p><b>Age:</b> Younger cats (Kogan &amp; Grigg, 2021; Yamada et al., 2020); Adult cats (Hart et al., 2018; Heidenberger, 1997; Wassink-van der Schot et al., 2016); Older cats (Barcelos et al., 2018; Finka et al., 2019; Yamada et al., 2020); Senior cats (Heidenberger, 1997)</p> <p><b>Sex:</b> Males (Bamberger &amp; Houpt, 2006; Pryor et al., 2001; Takeuchi &amp; Mori, 2009; Wassink-van der Schot et al., 2016); Females (Heidenberger, 1997; Paz et al., 2017)</p> <p><b>Pedigree:</b> (Amat et al., 2009; Bamberger &amp; Houpt, 2006; Takeuchi &amp; Mori, 2009; Tamimi et al., 2015; Wassink-van der Schot et al., 2016)</p> <p><b>Medical condition:</b> (Finka et al., 2019)</p> <p><b>Declawed:</b> (Gerard et al., 2016; Grigg &amp; Kogan, 2019)</p> <p><b>Neutered:</b> Yes (Adamelli et al., 2005; Heidenberger, 1997); No (Amat et al., 2009; Grigg &amp; Kogan, 2019; Sandøe et al., 2017)</p>
<p><b>Physical environment</b></p>	<p><b>Lifestyle:</b> Outdoor access (Barcelos et al., 2018; de Souza Machado et al., 2020a; Heidenberger, 1997; Tamimi et al., 2015)</p> <p><b>Certain toys available:</b> (Strickler &amp; Shull, 2014)</p> <p><b>Area type: City</b> (Heidenberger, 1997)</p> <p><b>More cat-specific items (e.g. scratching post,</b></p>	<p><b>Lifestyle:</b> Indoor-only (Amat et al., 2009; de Souza Machado et al., 2020a; de Souza Machado et al., 2020b; Finka et al., 2019; Kogan &amp; Grigg, 2021; Sandøe et al., 2017; Schubnel &amp; Arpaillange, 2008); Restricted outdoor access compared to unrestricted (Finka et al., 2019; Heidenberger, 1997; Schubnel &amp; Arpaillange, 2008); Uncontrolled outdoor access compared to controlled (Barcelos et al., 2018); Outdoor access (Grigg &amp; Kogan, 2019; Ramos &amp; Mills, 2009); More time outside (Strickler &amp; Shull, 2014)</p> <p><b>Certain toys available:</b> (Kogan &amp; Grigg, 2021; Strickler &amp; Shull, 2014)</p>

	<b>litter tray):</b> (Mengoli et al., 2013)	<b>No toys:</b> (de Souza Machado et al., 2020a) <b>Area type:</b> Suburbs (Heidenberger, 1997) <b>Fewer cat-specific items (e.g. scratching post, litter tray):</b> (Lawson et al., 2019) <b>House type: Apartment</b> (Yamada et al., 2020) <b>Less space per cat:</b> (Heidenberger, 1997)
<b>Social environment</b> *	<b>Multi-cat household:</b> Yes (Amat et al., 2009; Schubnel & Arpaillange, 2008; Yamada et al., 2020) <b>Several hours of owner interaction daily (compared to less often):</b> (Heidenberger, 1997) <b>Greater playtime bouts with owner:</b> (Strickler & Shull, 2014) <b>Greater owner experience:</b> (Heidenberger, 1997)	<b>Multi-cat:</b> Yes (Barcelos et al., 2018; Heidenberger, 1997; Lawson et al., 2019; Paz et al., 2017; Pryor et al., 2001); No (Hart et al., 2018; Strickler & Shull, 2014) <b>Less interaction with people:</b> (Tamimi et al., 2015) <b>No children:</b> (Heidenberger, 1997) <b>No other animals:</b> (de Souza Machado et al., 2020a) <b>Single adults and couples:</b> (Heidenberger, 1997) <b>Greater time spent alone:</b> (Heidenberger, 1997) <b>More female people in the house:</b> (de Souza Machado et al., 2020a)

## 2.4. COMPOSITE SCALES

Composite scales were created for three dimensions of the analysis i) physical environment, ii) social environment and iii) problem behaviours. For the environmental composites, the available literature suggests that the variables currently expected to impact problem behaviours can be broadly classified into these two groups (as seen in table 17). However, due to differing methodologies, results can be difficult to interpret due to inconsistent direction of effects. Composite scales were therefore used to reduce the likelihood of confusing and inconsistent results that may arise as the product of multiple testing of variables (as seen in table 17), to aid meaningful analysis. Composite scales additionally help to reduce the number of type-1 errors within an analysis by preventing multiple statistical comparisons of the same variable (Chen et

al., 2017). To reduce the chances of artificial grouping of variables within the composite scores, the three composites were designed to be distinctly different domains i.e. physical provisions and presence of humans or animals. The variables included in each composite were informed by the variables identified as significant within the literature search (table 17) and the expertise of the researcher, more details of which can be found below.

*PROBLEM BEHAVIOUR SCORE:* A composite scale for problem behaviours was created to provide an overview of both the range of behaviours displayed and the frequency with which they were displayed. Eleven behaviours were used to create the composite scores, as current literature suggests these behaviours can be perceived negatively by owners (Casey et al., 2009; Shore et al., 2008; Wassink-van der Schot et al., 2016) and that they may be influenced by environmental variables (table 17). The included behaviours were inappropriate elimination, vomiting, diarrhoea, constipation, scratching furniture, spraying, excessive vocalisation, aggression towards owners, aggression towards strangers, overgrooming and hiding at unexpected noise. Within the survey, owners were asked to rate how often their cat displayed these behaviours on a five-point Likert scale. Behaviours were coded based on the rating owners had assigned them within the survey. Those detailed to occur 'never' and 'rarely' were awarded 0 points, 'sometimes' 1 point, 'often' 2 points and 'always' 3 points. The frequencies of 'never' and 'rarely' were excluded from the composite as they were deemed unlikely to be problematic to owners when occurring at such a low frequency. Points for each behaviour were summed to give an overall score per cat.

*ENRICHMENT SCORE:* This composite contained provisions deemed important for cats with regards to their behavioural needs. Items included within the composite were vertical enrichment, cat beds, hiding areas, scratching objects, toys and litter tray. Sources of food or water were not included, as these were deemed to be fundamental provisions without which the cat could not survive, rather than additional enrichment items. Within the survey, owners were asked to detail whether they specifically provide these items for their cat inside their home. One point was awarded (per item) if the item was present in the home. Points were summed to give an overall environmental composite score per cat. A selection of these items have previously been linked to problem behaviours, such as the presence of scratching posts. Wilson et al. (2016) demonstrated that with increasing types and styles of scratching posts present in the home, furniture scratching decreased. Other items more generally aim to meet behavioural needs, such as toys facilitating hunting behaviour or a hiding area providing a secure resting area or a retreat from stressful situations. A higher score on this scale may suggest greater owner awareness of their cats' behavioural needs and a resolve to actively meet them.

*SOCIAL SCORE:* The social score aimed to capture detail about the social diversity and intensity within the immediate household of the cat. One point was awarded for each of the following: presence of (at least) one adult other than the owner, presence of (at least) one person aged 17 or under, presence of (at least) one other cat and the presence of (at least one) dog within the home. As one adult (the owner) was present in all households this was not included in the composite as it was considered a baseline for all cats, however, adults in addition to the main owner may represent an added source of social interaction, both positive or negative, and so a point was assigned if more than one adult lived within the household. People aged 17 and under were classified in their own category due to the different experiences they may introduce within the social environment of the household, such as louder noises and unpredictability, a differentially active social life, and different types of interaction with animals when compared to an adult. Other cats were included in the social composite score due to literature suggesting the presence or absence of other cats may significantly impact problem behaviours, through mechanisms such as competition for resources, territorial behaviour or affiliative behaviour (Finka & Foreman-Worsley, 2021: Chapter 2). Finally, dogs were included as an additional source of social interaction which may have positive or negative implications on problem behaviours in cats. Literature on intra-specific cat and dog relationships is currently scarce, as identified in Foreman-Worsley & Farnworth (2019: Chapter 1), however that which is available suggests the possibility of amicable relationships, although this might not always be the case (Feuerstein & Terkel, 2008; Thomson et al., 2018).

## 2.5. DATA ANALYSIS

All analysis took place in Microsoft Excel (Version 2002, Microsoft, Washington, DC, USA) and IBM SPSS (Version 26, New York, NY, USA).

### 2.5.1. DIFFERENCES BETWEEN LIFESTYLES

To check for significant differences in the levels of individual variables within the three major domains (social environment, enrichment and problem behaviours) between cats of different lifestyles, Chi<sup>2</sup> tests were performed.

Kruskal Wallis tests were performed to identify if there were significant differences between the three composite scores (environment, social and problem behaviour), across the three lifestyles (indoor-only, managed indoor-outdoor and unrestricted indoor-outdoor). As all three composite scores were identified as being significantly different between the three lifestyle groups (behaviour composite  $H(2) = 7.790$ ,  $p=0.20$ ; enrichment composite  $H(2) = 745.324$ ,  $p<0.01$ ; social composite  $H(2) = 32.245$ ,  $p<0.01$ ), Mann-Whitney U tests were then used to determine

the direction of effect of these differences. A significance threshold of  $p < 0.05$  was retained for this analysis despite multiple comparisons being made. It was considered that due to the large sample sizes in each group type-2 errors would be low and reducing the significance threshold would be more likely to introduce type-1 errors (Nakagawa, 2004). Mean rank scores were used to illustrate the differences between the lifestyles and determine the direction of effects, as the distribution of responses for each variable was not normal. Effect sizes were calculated for the results of the Mann-Whitney U test to determine how meaningful any differences were. The following formula was used:

$$r = \frac{z}{\sqrt{N}}$$

Where  $r$  = effect size,  $z$  = obtained from the Mann Whitney U test and  $N$  = sample size. Proportion of variance ( $PV$ ) for these effect sizes were then calculated using the formula:

$$PV = r^2$$

This value was presented as a percentage to allow meaningful interpretation (Cohen, 1988).

#### 2.5.2. GENERALISED LINEAR MODELS

To investigate which variables may impact problem behaviour scores across the three lifestyles, three generalised linear models were executed with problem behaviour score as the dependant variable. A Poisson loglinear model was selected due to the dependant variable being count data, being small in nature and having a Poisson distribution. Explanatory variables were manually selected for their biological relevance using currently available literature (table 17) and author expertise in the area to guide the choices, utilising composite scores where appropriate (see 2.2.3.1.). The variables included within the model were lifestyle, cat sex, cat life stage, pedigree status, medical issues, residential area type (e.g. urban, rural), number of rooms the cat has access to, how many daily hours the cat is alone without people in the house, the social score and the environmental score. The variable names, their descriptions and scale ranges or categorical levels are detailed in table 18. Neuter and declaw status were also identified in the literature as potential factors that influence problem behaviours, however, these variables were not included within the models as most cats in this study were neutered (96.4%, 4865/5048) and not declawed (97.9%, 4941/5048), resulting in grossly unbalanced categories unsuitable for analysis.

**Table 18, Variables included within the models:** A list of the variables included in the model and their descriptions.

Variable	Description	Categories
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<b>Lifestyle</b>	Level of outdoor access the cat is provided with	Indoor-only, managed indoor-outdoor, unrestricted indoor-outdoor
<b>CatSex</b>	Sex of the cat	Female, male
<b>CatLifeStage</b>	Categorised age of the cat	Kitten (0-6 months), junior (7 months-2 yrs), adult (3-7 yrs), mature (8-11 yrs), senior (12-15 yrs), super senior (16+ yrs)
<b>Medical</b>	Whether the cat has ongoing medical issues or not	Yes, no
<b>AreaType</b>	The type of area in which the cat and owner live	City centre, urban, suburban, village, rural
<b>RoomAccess</b>	Number of rooms within the house the cat has access to	Numeric scale starting at 1
<b>EnrichComp</b>	Enrichment composite score (see 2.2.3.1)	Numeric scale from 0-6
<b>SocialComp</b>	Social composite score (see 2.2.3.1)	Numeric scale from 0-4
<b>HoursAlone</b>	Daily hours the cat is left without people in the house	Numeric scale from 0-24
<b>Pedigree</b>	Whether the cat is a purebred	Yes, no, unsure

### 3. RESULTS

#### 3.1. DEMOGRAPHICS

A total of 5048 usable responses were retained after cleaning. The largest respondent demographics were female (88.7%, 4479/5048) and between the ages of 26-35 (29.4%, 1484/5048). European respondents were the most represented at 74.4% (3758/5048), followed by North Americans and Canadians at 19.8% (1001/5048). Adult cats represented the largest life stage category (32.8%, 1654/5048), sex ratio was effectively equal (female, 50.7%, 2557/5048), and the majority were of no specific breed (i.e. domestic short hair, domestic long hair, or cross breed) (82.2%, 4147/5058), neutered (96.4%, 4865/5048) and not declawed (97.9%, 4941/5048), with no ongoing medical conditions (83.4%, 4209/5048).

##### 3.1.1. LIFESTYLE

Owners with indoor-only cats accounted for 41% (2072/5048) of respondents, whilst 59% (2976/5048) had cats with outdoor access. Of cats with outdoor access, 35.5% (1056/2976) had unrestricted indoor-outdoor lifestyles e.g. a permanently open cat flap or window through which cats could enter and exit the home at will at any time of the day, and once outdoors, were able to roam freely. 64.5% (1920/2976) had managed indoor-outdoor lifestyles e.g. they were reliant on owners opening or closing doors, they were supervised at all times whilst outdoors, were walked on a leash or their outdoor space was limited to the garden, a catio or a run.



### 3.1.2. ENVIRONMENT

Overall, most households (79%, 3990/5048) contained adults in addition to the owner responding to the survey, whilst just 19.7% (996/5048) of households contained children 17 or under. Slightly over half of households were multi-cat households (53.6%, 2705/5048), whilst only 17.6% (887/50) of households contained dogs. Significant differences between lifestyles were seen for all four variables in the social environment, as seen in table 19.

Across all lifestyles, almost all cats were provided with an indoor water source (98.8%, 4981/5048), food source (99.2%, 5008/5048) and toys (96.6%, 4876/5048). The majority were provided with a litter tray (85.6%, 4321/5048), scratching items (86.4%, 4361/5048), hiding spots (82.3%, 4155/5048) and cat beds (74.0%, 3736/5048). Over half were provided with vertical enrichment such as cat trees or shelving (60.8%, 3017/5048). Significant differences in levels of enrichment provided between lifestyles was found for litter trays ( $\chi^2=1289.21$ ,  $p<0.00$ ), scratching posts ( $\chi^2=230.61$ ,  $p<0.00$ ), toys ( $\chi^2=98.22$ ,  $p<0.00$ ), vertical enrichment ( $\chi^2=351.17$ ,  $p<0.00$ ), hiding spots ( $\chi^2=182.30$ ,  $p<0.00$ ) and beds ( $\chi^2=72.21$ ,  $p<0.00$ ), which was all items besides food and water bowls. A full breakdown of the provisions provided across each lifestyle can be found in table 20.

**Table 19, Social demographics of owners across lifestyles:** Social environments and presence of adults, children, other cats and dogs within the households as a total and percentage, both overall, and broken down across the three lifestyles, alongside the Chi<sup>2</sup> value and p-value to test any significant associations between the lifestyle owners provide and the social environment within those homes.

Social aspect	All lifestyles (n=5048)	Indoor-only (n=2072)	Managed indoor-outdoor (n=1920)	Unrestricted indoor-outdoor (n=1056)	Chi <sup>2</sup> (degrees of freedom)	p-value
<b>Adults other than owner within household</b>	79.0%	75.3% (1561)	81.7% (1568)	81.5% (861)	29.10 (2)	<b>&lt;0.00</b>
<b>Children within household</b>	19.7%	15.5% (322)	21.6% (414)	24.6% (260)	42.98 (2)	<b>&lt;0.00</b>
<b>Dogs within household</b>	17.6%	16.1% (334)	17.3% (332)	20.9% (221)	11.33 (2)	<b>&lt;0.00</b>
<b>Other cats within household</b>	53.6%	56.5% (1171)	48.5% (931)	57.1% (603)	32.45 (2)	<b>&lt;0.00</b>

**Table 20, Provisions provided by owners across lifestyles:** The total number and percentage of owners who provide different items for their cats, as a whole and broken down across the three lifestyles, alongside the Chi<sup>2</sup> value and p-value to test any significant associations between the lifestyle owners provide and the number of owners providing different items for their cat.

Item provided	All lifestyles (n=5048)	Indoor-only (n=2072)	Managed indoor-outdoor (n=1920)	Unrestricted indoor-outdoor (n=1056)	Chi <sup>2</sup> (degrees of freedom)	p-value
Litter tray	85.6%	98.2% (2035)	90.7% (1741)	51.8% (547)	1289.21 (2)	<0.00
Scratching post/pole	86.4%	94.8% (1964)	82.8% (1589)	76.7% (810)	230.61 (2)	<0.00
Toys (independent play or owner-interactive)	96.6%	99.5% (2061)	95.4% (1831)	93.2% (984)	98.22 (2)	<0.00
Food source (inc. enrichment)	99.2%	99.3% (2057)	99.1% (1902)	99.1% (1047)	0.56 (2)	0.76
Water source (inc. fountains)	98.7%	98.9% (2050)	98.7% (1895)	98.1% (1036)	3.71 (2)	0.16
Vertical enrichment	59.8%	74.8% (1549)	52.5% (1008)	43.6% (460)	351.17 (2)	<0.00
Hiding spot	82.3%	90.4% (1873)	79.1% (1519)	72.1% (761)	182.30 (2)	<0.00
Cat bed	74.0%	80.0% (1657)	71.1% (1366)	67.1% (709)	72.21 (2)	<0.00

**Table 21, Problem behaviours reported by owners across lifestyles:** The total number and percentage of cats reported to display problem behaviours, both for the population as a whole, and broken down across the three lifestyles, alongside the Chi<sup>2</sup> value and p-value to test any significant associations between the lifestyle owners provide and the number of cats displaying different behaviours.

<b>Problem behaviour</b>	<b>All lifestyles (n=5048)</b>	<b>Indoor-only (n=2072)</b>	<b>Managed indoor- outdoor (n=1920)</b>	<b>Unrestricted indoor-outdoor (n=1056)</b>	<b>Chi<sup>2</sup> (degrees of freedom)</b>	<b>p-value</b>
<b>Elimination problems</b>	27.3%	28.1% (582)	28.7% (551)	23.1% (224)	22.03 (2)	<b>&lt;0.00</b>
<b>Vomiting</b>	68.0%	68.1% (1410)	68.4% (1313)	67.3% (711)	0.35 (2)	0.84
<b>Diarrhoea</b>	37.6%	37.7% (782)	42.9% (823)	27.7% (292)	67.26 (2)	<b>&lt;0.00</b>
<b>Constipation</b>	18.9%	19.8% (411)	20.4% (392)	14.3% (151)	18.65 (2)	<b>&lt;0.00</b>
<b>Scratching furniture</b>	75.6%	74.7% (1548)	76.4% (1466)	76.7% (810)	2.12 (2)	0.35
<b>Spraying</b>	9.7%	5.6% (116)	11.5% (220)	14.7% (155)	76.26 (2)	<b>&lt;0.00</b>
<b>Excessive vocalisation</b>	59.5%	60.5% (1253)	60.5% (1161)	55.8% (589)	7.64 (2)	<b>0.02</b>
<b>Aggression towards owner</b>	25.2%	22.5% (467)	27.3% (524)	26.4% (279)	13.09 (2)	<b>&lt;0.00</b>
<b>Aggression towards strangers</b>	19.2%	17.6% (365)	21.0% (404)	19.0% (201)	7.56 (2)	<b>0.02</b>
<b>Overgrooming</b>	25.7%	24.5% (507)	26.7% (513)	26.3% (278)	2.90 (2)	0.23
<b>Hiding at unexpected noise</b>	65.3%	65.3% (1353)	65.7% (1261)	64.6% (682)	0.36 (2)	0.84

### 3.1.3. PROBLEM BEHAVIOURS

The most reported problem behaviour was furniture scratching, with 75.6% (3824/5048) of owners reporting their cat scratches the furniture. The least reported problem behaviour was spraying, with only 9.7% (491/5048) of cats reportedly spraying. The behaviours found to significantly differ between lifestyles were elimination problems ( $\chi^2=22.03$ ,  $p<0.00$ ), diarrhoea ( $\chi^2=67.26$ ,  $p<0.00$ ), constipation ( $\chi^2=18.65$ ,  $p<0.00$ ), spraying ( $\chi^2=72.26$ ,  $p<0.00$ ), excessive vocalisation ( $\chi^2=7.64$ ,  $p=0.02$ ), aggression towards owners ( $\chi^2=13.09$ ,  $p<0.00$ ) and aggression towards strangers ( $\chi^2=7.56$ ,  $p=0.02$ ). A full breakdown of the problem behaviours observed can be viewed in table 21, with additional detail provided for the prevalence of behaviours across the different lifestyles.

## 3.2. COMPARISON OF COMPOSITE SCORES BETWEEN LIFESTYLES

### 3.2.1. PROBLEM BEHAVIOUR SCORES

Mann-Whitney U tests revealed significant differences in the problem behaviour scores across the three lifestyles. Significantly higher scores (indicating a higher frequency and/or greater diversity of reported problem behaviours)( $U=1030151.5$ ,  $Z=-2.698$ ,  $p=0.007$ ) were seen in indoor-only cats compared to cats with unrestricted indoor-outdoor access. Cats with managed indoor-outdoor lifestyles were also found to have significantly higher ( $U=963763.5$ ,  $Z=-2.251$ ,  $p=0.024$ ) scores than cats with unrestricted indoor-outdoor access. There was no significant difference between the problem behaviour scores for indoor-only and managed indoor-outdoor cats ( $U=1967197$ ,  $Z=-0.608$ ,  $p=0.543$ ). However, associated effect sizes were almost negligible, and accounted for 0.23% and 0.17% of the variance seen respectively. These results, plus mean rank scores, can be seen in table 22 and are displayed visually in figure 3.

### 3.2.2. ENRICHMENT

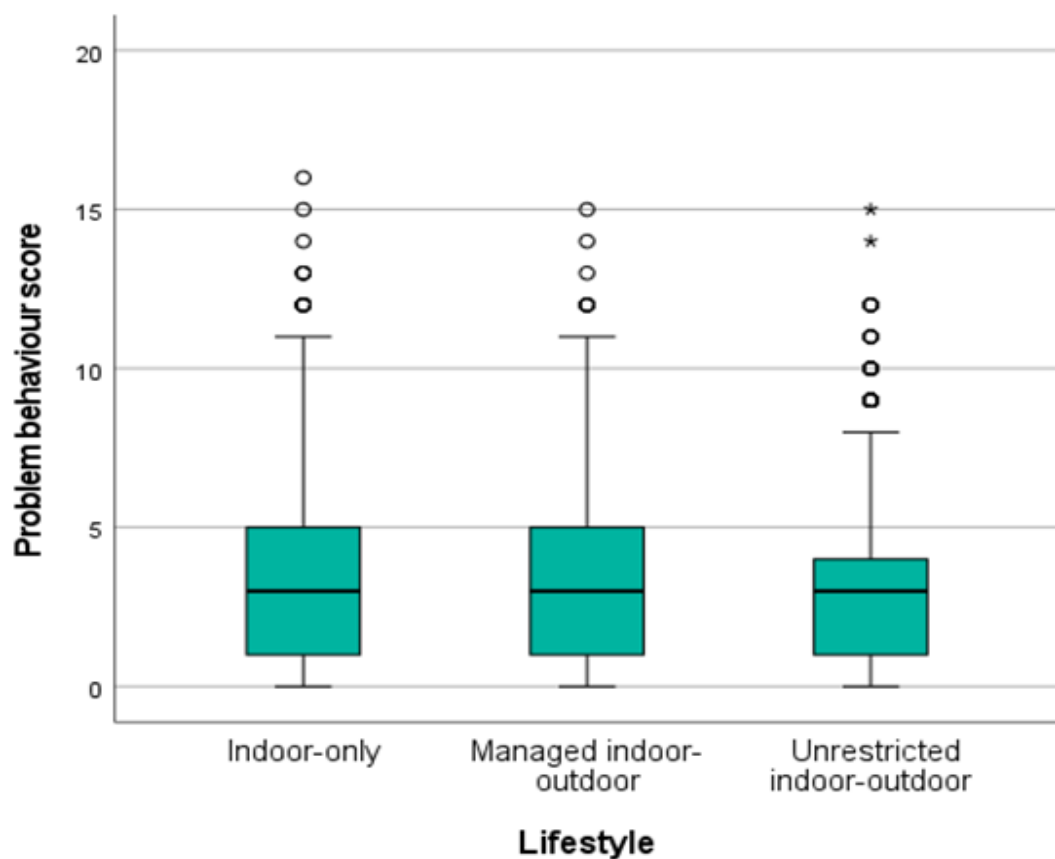
Indoor-only cats had significantly higher ( $U=501324$ ,  $Z=-26.332$ ,  $p<0.001$ ) enrichment scores than those with unrestricted indoor-outdoor access, as well as those with managed indoor-outdoor access ( $U=1398257$ ,  $Z=-17.408$ ,  $p<0.001$ ). Cats with managed indoor-outdoor access also had significantly higher ( $U=744895.5$ ,  $Z=-12.337$ ,  $p<0.001$ ) enrichment scores than unrestricted indoor-outdoor cats. Effect sizes of 22.17%, 5.11% and 7.59%, respectively, were seen. These results can be seen in table 22 and are displayed visually in figure 4.

### 3.2.3. SOCIAL

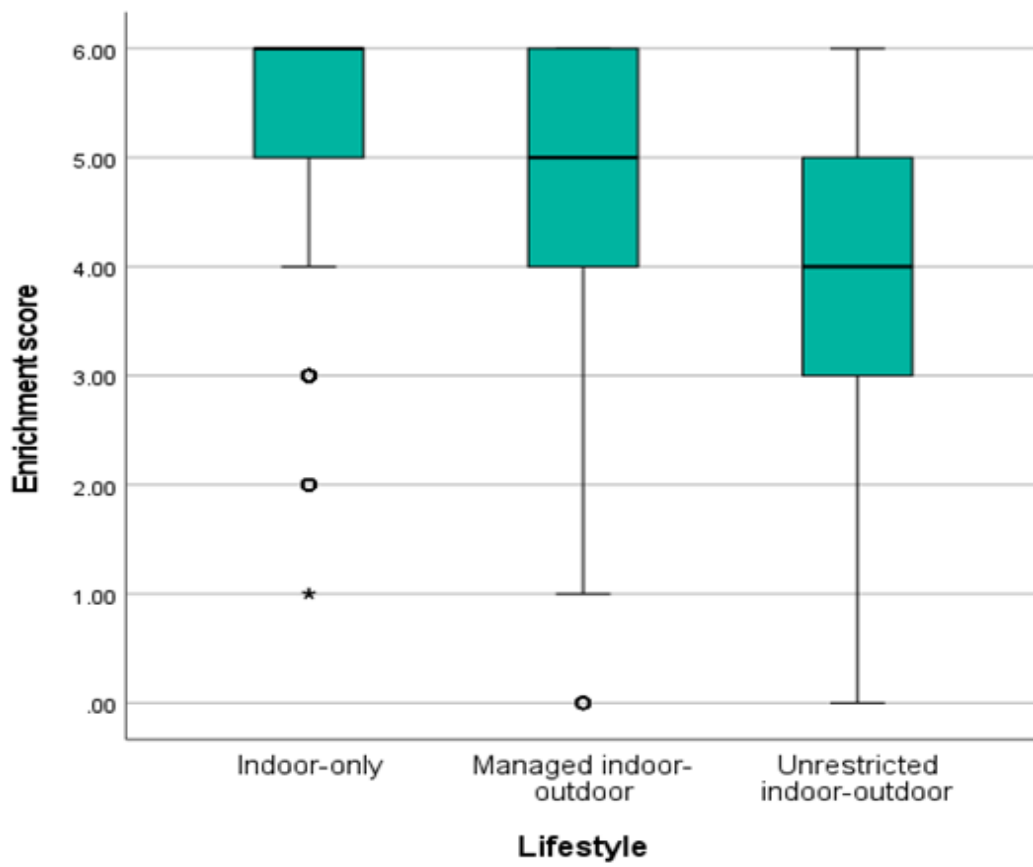
Indoor-only cats had significantly lower ( $U=1936321$ ,  $Z=-1.5$ ,  $p<0.001$ ) social scores than unrestricted indoor-outdoor cats, meaning the social environment of indoor-only cats was

typically less complex than those of cats with unrestricted indoor-outdoor access. Unrestricted indoor-outdoor cats had significantly higher ( $U=921780$ ,  $Z=-4.322$ ,  $p<0.001$ ) social scores than managed indoor-outdoor cats. No significant difference was found between indoor-only and managed indoor-outdoor cats ( $U=1936321$ ,  $Z=-1.533$ ,  $p=0.125$ ). Effect size was again small, accounting for 1.00% and 0.63% of variance respectively. These results can be seen in table 22 and are displayed visually in figure 5.

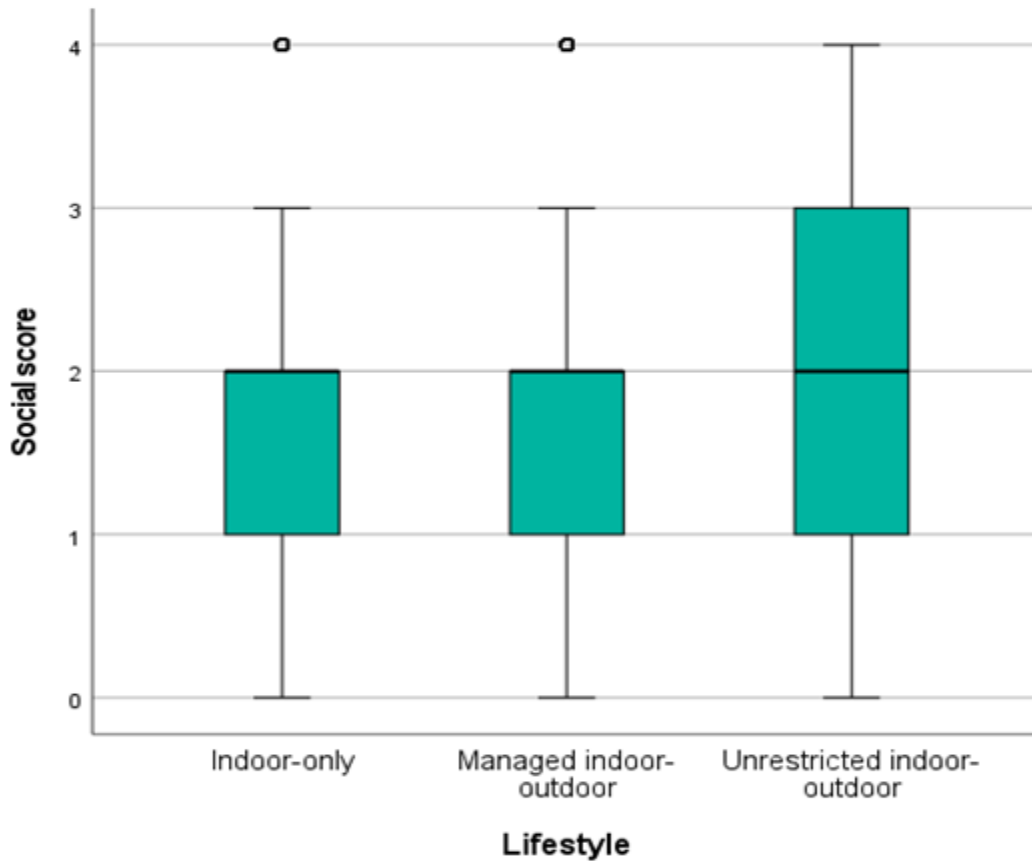
**Figure 3, Box and whisker plots for problem behaviour scores across lifestyles:** Box and whisker plots showing the median score, interquartile ranges, minimum and maximum values and outliers for problem behaviour scores across the three lifestyles.



**Figure 4, Box and whisker plots for enrichment scores across lifestyles:** Box and whisker plots showing the median score, interquartile ranges, minimum and maximum values and outliers for enrichment score across the three lifestyles.



**Figure 5, Box and whisker plots for social scores across lifestyles:** Box and whisker plots showing the median score, interquartile ranges, minimum and maximum values and outliers for social scores across the three lifestyles.



### 3.3. LIFESTYLE MODELS

#### 3.3.1. INDOOR-ONLY CATS

Problem behaviour scores significantly decreased with increasing enrichment ( $p < 0.001$ ,  $\text{Exp}(B) = 0.929$ , 95% CI = 0.905-0.953) and as the number of rooms the cat has access to increased ( $p < 0.001$ ,  $\text{Exp}(B) = 0.972$ , 95% CI = 0.961-0.983). Kitten ( $p < 0.001$ ,  $\text{Exp}(B) = 0.727$ , 95% CI = 0.609-0.868) and junior ( $p = 0.027$ ,  $\text{Exp}(B) = 0.932$ , 95% CI = 0.876-0.992) cats were more likely to have lower problem behaviour scores than adult cats. Mature ( $p = 0.013$ ,  $\text{Exp}(B) = 1.092$ , 95% CI = 1.019-1.171) and senior ( $p < 0.001$ ,  $\text{Exp}(B) = 1.198$ , 95% CI = 1.104-1.300) cats were more likely to have higher problem behaviour scores than adults.

#### 3.3.2. MANAGED INDOOR-OUTDOOR CATS

Problem behaviour scores decreased with increasing social scores ( $p < 0.001$ ,  $\text{Exp}(B) = 0.921$ , 95% CI = 0.895-0.948). Urban ( $p = 0.031$ ,  $\text{Exp}(B) = 0.877$ , 95% CI = 0.778-0.988), village ( $p = 0.002$ ,



Exp(B)=0.827, 95% CI=0.733-0.932) and rural areas ( $p=0.014$ , Exp(B)=0.850, 95% CI=0.746-0.967) all had cats with lower problem behaviour scores when compared to those living in city centres. The only area not significantly different to the reference category of the city centre were suburban areas. Cats with medical issues were more likely to have higher problem behaviour scores when compared to cats with no medical issues ( $p<0.001$ , Exp(B)=1.219, 95% CI=1.139-1.304).

Junior ( $p=0.002$ , Exp(B)=0.892, 95% CI=0.829-0.959) cats were more likely to have lower problem behaviour scores than adult cats. Senior ( $p=0.012$ , Exp(B)=1.105, 95% CI=1.022-1.195) and super senior ( $p=0.039$ , Exp(B)=1.125, 95% CI=1.006-1.257) cats were more likely to have higher problem behaviour scores than adults. Cats whose owners were unsure on their pedigree status were more likely to have higher problem behaviour scores than cats who were non-pedigree ( $p=0.25$ , Exp(B)=1.119, 95% CI=1.014-1.234).

### 3.3.3. UNRESTRICTED INDOOR-OUTDOOR CATS

Problem behaviour scores increased as hours alone increased ( $p=0.046$ , Exp(B)=1.012, 95% CI=1.000-1.023) and as enrichment scores increased ( $p=0.005$ , Exp(B)=1.036, 95% CI=1.011-1.062). Problem behaviour scores decreased with increasing social scores ( $p=0.022$ , Exp(B)=0.957, 95% CI=0.921-0.994). As with managed indoor-outdoor cats, urban ( $p=0.022$ , Exp(B)=0.816, 95% CI=0.685-0.972), suburban ( $p=0.006$ , Exp(B)=0.793, 95% CI=0.673-0.935), village ( $p=0.008$ , Exp(B)=0.792, 95% CI=0.667-0.941) and rural ( $p<0.001$ , Exp(B)=0.647, 95% CI=0.535-0.782) area types all had lower problem behaviour scores than the city centre.

As seen in cats with managed indoor-outdoor access, cats with medical issues were more likely to have higher problem behaviour scores when compared to cats with no medical issues ( $p<0.001$ , Exp(B)=1.222, 95% CI=1.107-1.348). Females had lower problem behaviour scores than males ( $p<0.001$ , Exp(B)=1.226, 95% CI=1.110-1.353). Again, junior ( $p=0.002$ , Exp(B)=0.843, 95% CI=0.757-0.940) cats were more likely to have lower problem behaviour scores than adult cats, and senior cats ( $p=0.022$ , Exp(B)=1.130, 95% CI=1.018-1.254) were more likely to have higher problem behaviour scores than adults.

**Table 22, Descriptive statistics for problem behaviour, social and environmental scores across lifestyles:** Descriptive statistics (range, mean, standard error (SE), standard deviation (SD) and variance) for the problem behaviour scores of all cats (n=5048), and across the three lifestyles – indoor-only (n=2072), managed indoor-outdoor (managed IO) (n=1920) and unrestricted indoor-outdoor (unrestricted IO) (n=1056). Results of the Mann-Whitney U tests comparing problem behaviour scores, environment scores and social scores between the three lifestyles. Significant results are marked with an asterisk (\*).

Composite	Descriptive statistics							Mann-Whitney U tests				
	Population	Possible range	Displayed range	Mean	Mean SE	SD	Variance	Groups compared	Significance	Direction of effect	Mean rank	Variance (%)
Problem behaviour score	All (n=5048)	0-33	0-16	3.16	0.034	2.419	5.850					
	Indoor-only (n=2072)		0-16	3.23	0.054	2.459	6.045	Indoor-only and unrestricted IO	p = 0.007*	Indoor-only > unrestricted IO	1595.32 1504.02	0.23
	Managed IO (n=1920)		0-15	3.17	0.054	2.353	5.538	Indoor-only and managed IO	p = 0.558	N/A	2007.08 1985.08	0.01
	Unrestricted IO (n=1056)		0-15	3.01	0.075	2.453	6.015	Unrestricted IO and managed IO	p = 0.024*	Unrestricted IO < managed IO	1441.15 1514.54	0.17
Enrichment score	All (n=5048)	0-6	0-6	4.85	0.02	1.300	1.691					
	Indoor-only (n=2072)		1-6	5.38	0.02	0.892	0.796	Indoor-only and unrestricted IO	p = <0.001*	Indoor-only > unrestricted IO	1850.55 1003.24	22.17
	Managed IO (n=1920)		0-6	4.71	0.03	1.303	1.700	Indoor-only and managed IO	p = <0.001*	Indoor-only > managed IO	2281.67 1688.76	7.59
	Unrestricted IO (n=1056)		0-6	4.04	0.05	1.486	2.209	Unrestricted IO and managed IO	p = <0.001*	Unrestricted IO < managed IO	1233.89 1628.53	5.11
Social score	All (n=5048)	0-4	0-4	1.70	0.130	0.944	0.891					
	Indoor-only (n=2072)		0-4	1.64	0.210	0.939	0.882	Indoor-only and unrestricted IO	p = <0.001*	Indoor-only < unrestricted IO	1503.33 1684.53	1.00
	Managed IO (n=1920)		0-4	1.69	0.021	0.925	0.856	Indoor-only and managed IO	p = 0.125	N/A	1971.02 2024.00	0.06
	Unrestricted IO (n=1056)		0-4	1.84	0.030	0.972	0.945	Unrestricted IO and managed IO	p = <0.001*	Unrestricted IO > managed IO	1575.60 1440.59	0.63

**Table 23, GLM results of variables significant in predicting problem behaviour scores across lifestyles:** Results from the three separate GLMs (one per lifestyle) indicating the significant variables (in bold), and the direction of effect each variable has upon the problem behaviour score (PBS).

Variable	Indoor-only (n=2062)				Managed indoor-outdoor (n=1905)				Unrestricted indoor-outdoor (n=1053)			
	Wald $\chi^2$	df	Sig.	Direction of effect	Wald $\chi^2$	df	Sig.	Direction of effect	Wald $\chi^2$	df	Sig.	Direction of effect
<b>Cat Sex</b>	.000	1	.994		.135	1	.713		<b>22.554</b>	<b>1</b>	<b>&lt;.001</b>	Decreased PBS in males compared to females
<b>Cat Life stage</b>	<b>55.414</b>	<b>5</b>	<b>&lt;.001</b>	Decreased PBS in kittens and juniors, increased PBS in mature and senior cats compared to adults	<b>31.852</b>	<b>5</b>	<b>&lt;.001</b>	Decreased PBS in kittens, increased PBS in senior and super senior cats compared to adults	<b>24.761</b>	<b>4</b>	<b>&lt;.001</b>	Decreased PBS in juniors, increased PBS in senior cats compared to adults
<b>Medical</b>	3.063	1	.080		<b>33.042</b>	<b>1</b>	<b>&lt;.001</b>	Increased PBS in cats with medical issues	<b>16.238</b>	<b>1</b>	<b>&lt;.001</b>	Increased PBS in cats with medical issues
<b>Pedigree</b>	.559	2	.756		<b>6.312</b>	<b>2</b>	<b>.043</b>	Increased PBS in cats with unknown pedigree status, compared to non-pedigree	2.899	2	.235	
<b>Area Type</b>	4.420	4	.352		<b>14.398</b>	<b>4</b>	<b>.006</b>	Decreased PBS in urban, village and rural areas compared to city centres	<b>22.529</b>	<b>4</b>	<b>&lt;.001</b>	Decreased PBS in urban, suburban, village and rural areas compared to city centres
<b>Room Access</b>	<b>24.859</b>	<b>1</b>	<b>&lt;.001</b>	Decreasing PBS with increasing room number	.002	1	.969		.387	1	.534	
<b>Enrich Comp</b>	<b>30.951</b>	<b>1</b>	<b>&lt;.001</b>	Decreasing PBS with increasing enrichment score	<b>.852</b>	<b>1</b>	.356		<b>7.791</b>	<b>1</b>	<b>.005</b>	Increasing PBS with increasing enrichment score
<b>Hours Alone</b>	.602	1	.438		2.166	1	.141		<b>3.998</b>	<b>1</b>	<b>.046</b>	Increasing PBS with increasing hours alone
<b>Social Comp</b>	3.074	1	.080		<b>31.864</b>	<b>1</b>	<b>&lt;.001</b>	Decreasing PBS with increasing social score	<b>5.248</b>	<b>1</b>	<b>.022</b>	Decreasing PBS with increasing social score

## 4. DISCUSSION

### 4.1. PROBLEM BEHAVIOUR

This study provides further evidence that significant differences in owner-reported problem behaviours exist between cats of different lifestyles. Cats with unrestricted indoor-outdoor access had significantly lower problem behaviour scores than cats with indoor-only lifestyles. These findings are consistent with other papers that have generally demonstrated indoor-only cats have higher rates of problem behaviours than those with outdoor access (Amat et al., 2009; de Souza Machado et al., 2020a; de Souza Machado et al., 2020b; Finka et al., 2019; Kogan & Grigg, 2021; Sandøe et al., 2017; Schubnel & Arpaillange, 2008). Additionally, managed indoor-outdoor cats had significantly higher problem behaviour scores than unrestricted indoor-outdoor cats, but behaviour was not significantly different to indoor-only cats.

In the few other studies that have differentiated between types of outdoor access, comparable results have been found. Finka et al. (2019) report lower frequencies of sickness behaviours in cats with unrestricted outdoor access when compared to those that were indoor-only or had restricted outdoor access. Additionally, they report no significant differences between the behaviour of indoor-only and restricted indoor-outdoor cats. Sandøe et al. (2017) found that of the problem behaviours mentioned in their study, 54.7% of free-roaming outdoor cats did not display any, followed by 44.7% of cats confined to a garden, followed by 37.1% of indoor-only cats. These studies, alongside the results of this study, may suggest that generally, with increasing degrees of confinement, owner-reported problem behaviours increase.

The reasons why owner-reported problem behaviour scores are significantly higher in managed indoor-outdoor cats than those with unrestricted indoor-outdoor access could be the more limited choice and control a cat has over its environment in the managed scenario. This could be with regards to the ability to freely roam once outdoors, the length of time spent outdoors and the time budgets of activities undertaken outside, or the regularity and predictability of outdoor access. Cats have been shown to have preferred spots to occupy, which they can be regularly found at during specific time points during the day (Bernstein and Strack, 1996). It is possible that restricting a cat's capacity to access this spot, such as if the spot is

outside but owners are not always available to provide access, may cause stress or encourage attention-soliciting behaviours such as excessive vocalisation. It has also been demonstrated that cats with more predictable caretaking routines show less problem behaviours (Carlstead et al., 1993), and predictability may be less common for cats reliant on owners to provide access to the outdoors. These domains thus warrant further study. However, as no significant differences exist between cats with indoor-only or restricted indoor-outdoor lifestyles, and that overall effect sizes were small, this suggests that outdoor access alone is not responsible for the general decrease in reported problem behaviours between indoor-only and indoor-outdoor cats seen throughout much of the literature.

#### 4.2. ENRICHMENT AND PROVISIONS

This study shows that with decreasing levels of lifestyle confinement, levels of enrichment and provisions decrease. Indoor-only cats had significantly greater enrichment scores than managed and unrestricted indoor-outdoor cats, and managed cats had significantly higher scores than unrestricted cats. When looking at the percentages of owners who provide different items across different lifestyles (table 20), we see that for all items more indoor-only owners provide them than managed indoor-outdoor cat owners, and more managed indoor-outdoor cat owners provide them than unrestricted indoor-outdoor cat owners.

Significant differences were seen in the percentage of owners providing enrichment items for cats of different lifestyles. Some of the starkest differences in individual provisions in this study were 98.2% of indoor-only cats being provided with a litter tray versus 51.8% of unrestricted indoor-outdoor cats. Additionally, 94.8% of indoor-only cats were provided with a scratching post, compared to 76.7% of unrestricted indoor-outdoor cats. The little additional data that currently exists with regards to differences in provisions or the environment of cats with indoor-only or indoor-outdoor lifestyle shows similar trends. Lawson et al. (2019) found similar figures for scratching post provisions in Australian owners, with 92.4% of indoor-only cat owners providing a scratching post, compared to 71.2% of indoor-outdoor owners. Tan et al., (2021) grouped Canadian cats into those with uncontrolled outdoor access and those with no uncontrolled outdoor access (including indoor-only cats) and found all provisions investigated such as toys, scratching areas, vertical enrichment and olfactory enrichment were found to be

provided at a higher rate for cats with no uncontrolled outdoor access compared to those with uncontrolled outdoor access.

These results are important, as despite owners generally being reported to recognise the importance of enrichment for their cats (de Assis & Mills, 2021; Tan et al., 2021), there is seemingly a disparity between this recognition in owners of cats with different lifestyles. One explanation may be that a substantial portion of indoor-outdoor cat owners provide this lifestyle as they perceive it to be beneficial to the mental health of their cat (Foreman-Worsley et al., 2021: Chapter 3), thus they may feel indoor enrichment is not necessary. Another is that cat charities, veterinarians and behavioural experts often recommend providing additional enrichment for indoor-only cats (Cats Protection, 2015; Herron & Buffington, 2010; Scherk, 2021). Whilst it is positive to see evidence that owners may be responding to this advice, it is also important that cats with outdoor access are provided with enrichment items, alongside necessities such as litter trays or water sources, especially for those cats whose outdoor access might be restricted.

#### 4.3. SOCIAL ENVIRONMENT

This study suggests that as less-restricted outdoor access becomes available, social environments tend to get busier and more complex, as significantly higher social scores were seen for cats with unrestricted indoor-outdoor lifestyles compared to those with indoor-only lifestyles, and for cats with unrestricted compared to managed indoor-outdoor lifestyles. The analysis in Chapter 3 demonstrated that cats in multi-cat households are more likely to have outdoor access, and associations between multi-cat households and a greater likelihood of outdoor access have been reported in additional literature (Tan et al., 2021). It has also been reported that owners with dogs may be more likely to allow outdoor access to their cats (Clancy et al., 2003). It is possible that in busy households, owners have less time to dedicate time to their cat's care and so outside access is permitted. Alternatively, cats may be more inclined to signal a wish to access the outdoors to avoid the stress of the home.

As seen in Foreman-Worsley et al. (2021; Chapter 3), previous analysis has demonstrated cats with outdoor access are more likely to live in rural areas, and with older owners. These demographics may suggest partnered owners with larger houses, children and the potential to accommodate more animals. Indoor-only cats

were more likely to live with younger owners and in the city centre or urban environments. In these instances, housing typically tends to be smaller in footprint and thus may not be as accommodating of as many animals or people. The same study (Chapter 3) found a subset of owners who detailed they believe outdoor access was beneficial to their cat as it provided the opportunity for their cat to spend time away from conspecifics, children or dogs the cat cohabits with. This may suggest owners with more space, inclusive of outdoor space, feel it is more appropriate to have multiple animals.

#### 4.4. GLM RESULTS

##### *CAT SEX*

In unrestricted indoor-outdoor cats, male cats typically had higher problem behaviour scores than females. Where cat sex has been studied in relation to problem behaviours previously, results have been inconclusive as to a definitive direction of effect that sex may have (table 17). However, trends in reporting seem to suggest certain behaviours may be present at a higher incidence rate in one sex compared to another. In studies where males are reported to exhibit greater problem behaviours than females, these behaviours are often urine-related, such as inappropriate urination, housesoiling or urine-marking (Pryor et al., 2001; Strickler & Shull, 2014; Wassink-van der Schot et al., 2016). These behaviours are often linked to territorial marking and serve as intra-species communication that other cats are living in and patrolling the area. Cats with unrestricted outdoor access are more likely to encounter neighbouring cats, or territorial markings than managed indoor-outdoor or indoor-only cats, which could potentially increase the rate at which the study cat performs their own marking (Little, 2016). It is also possible that males who exhibited marking behaviours are given outdoor access to help reduce this behaviour indoors. As seen in table 21, spraying varied significantly between cats of different lifestyles, and was reported to occur in more unrestricted indoor-outdoor cats than indoor-only and managed indoor-outdoor cats (at 14.7%, 5.6% and 11.5% of cats respectively), therefore, this behaviour within the composite may contribute to the overall higher problem behaviour score in unrestricted indoor-outdoor males. Owners may reduce the rate at which their cats mark by ensuring cats that do not live within the household do not enter the household, by neutering their cat, and by ensuring cats have places to scratch and

rub within the house, as these acts also facilitate the marking of their territory with pheromones.

#### *LIFE STAGE*

Strong evidence was found to suggest life stage has significant associations with problem behaviour scores regardless of lifestyle. Typically, cats below adult age had lower problem behaviour scores than adults, and cats older than adult age had increased problem behaviour scores when compared to adults. The association between age and problem behaviours has been reported in many studies to date, as detailed in table 17, however, as previously discussed, the direction of effect has been inconsistent. The way variables are analysed might play a role in this, with many studies utilising age as a continuous variable. This study grouped cats into life stages, on the basis that cats in different life stages may act differently due to maturity, energy levels and relative life experience. In studies where age has been a continuous variable, more nuanced differences between problem behaviours of cats in different life stages may be missed, if ages at the extreme ends of the scale are not as well represented within the study population.

In this study, fewer problem behaviours were reported in younger cats compared to adults. Where problem behaviours are a potential indicator of stress, it may be that young cats are more resilient and better able to cope with their environment. Owners of younger cats or kittens may also have more access to advice regarding feline behaviour than owners of adult cats, if frequent veterinary appointments for vaccinations or neutering provides an opportunity to speak to veterinary professionals about management, care provision and behaviour concerns. Gazzano et al. (2015) demonstrate that owners who met with a veterinary professional more often in the first year of their kitten's life reported fewer problem behaviours than owners who met a veterinarian only once. The overall levels of neutering, vaccinations and microchipping within this study were high, suggesting these meetings with a veterinarian could play a role. However, it must also be considered that owners experience reporting biases for younger cats or kittens, interpreting some behaviours as normal, rather than as problematic. For example, owners may feel that furniture scratching or inappropriate elimination are to be expected until kittens are trained. There may also be biases within the recall of problem behaviour, lest they be viewed as less severe due to being less damaging e.g. aggression within a kitten may result in less severe injuries than aggression by an



adult cat, and so incidents of aggression are less likely to be remembered in kittens compared to adults.

Higher problem behaviour scores were reported in older cats compared to adults. Older cats may be affected more by their environment, and less able to cope with suboptimal living situations. Additionally, as cats age the likelihood of them developing medical issues increases. Medical issues have been linked to increased problem behaviours (Finka et al., 2019), and may result in symptoms perceived as problem behaviours. Older cats may also suffer from age-related cognitive dysfunction, many symptoms of which are often classed as problem behaviours (ASPCA, 2022; International Cat Care, 2018;). For example, house soiling or increased vocalisation may arise from cats becoming lost or disorientated within the home. As symptoms may increase gradually, and overt signs of sickness may not initially be present, these problem behaviours may be overlooked as being the result of a medical issue by owners, resulting in the condition going undiagnosed (Lansberg et al., 2012; Sordo et al., 2020). Raising awareness over the possibility that older cats may suffer from age-related cognitive dysfunction could be important in prompting owners to seek veterinary care and advice for older cats.

#### *MEDICAL CONDITIONS*

In cats with both managed and unrestricted indoor-outdoor access, increased problem behaviour scores were seen in cats with medical issues. Medical issues are well correlated with problem behaviours, either as a side-effect or symptom of conditions. For example, chronic pain may increase aggression as a defensive mechanism towards handling or social activity (Amat et al., 2016), or lead to directed overgrooming towards the affected area (Horwitz & Rodan, 2018). Gastrointestinal concerns such as irritable bowel disorder may result in inappropriate elimination if cats are unable to make it to the litter box on time, or bouts of diarrhoea and/or vomiting (Jergens, 2012).

Existence of a medical condition has previously been identified as a predictor for an indoor-only lifestyle (Foreman-Worsley et al., 2021; Tan et al., 2021), however, this study suggested an association between medical issues and problem behaviours in cats with outdoor access. Chronic pain conditions such as arthritis have previously been suggested to increase the occurrence of house-soiling (Klinck et al., 2012; Neilson, 2004), yet fewer indoor-outdoor cats are provided with litter trays than

indoor-only cats. The absence of a litter tray may contribute towards problem behaviours such as inappropriate elimination in cats with outdoor access if cats struggle to go outdoors to toilet. It is important that owners are aware that medical conditions may increase the prevalence and frequency of problem behaviours and that owners are supported in managing these behaviours. This should include recommendations of essential items such as litter trays particularly for outdoor cats with medical conditions. Should owners not be supported, problems may lead to relinquishment to shelters (Alberthsen et al., 2016; Jensen et al., 2020; Powell et al., 2021; Salman et al., 1998) where animals may be euthanised if they cannot be rehomed (Hawes et al., 2018). Similarly owners may request euthanasia in cases where animals could have a good quality of life if the condition was managed (Kass et al., 2001; Yeates & Main, 2011).

#### *PEDIGREE STATUS*

In cats with managed indoor-outdoor lifestyles, cats of unknown pedigree status were more likely to have higher problem behaviour scores than non-pedigree cats. Although research into behavioural differences across breeds of cat is less developed than that into dogs, there is evidence to suggest differences in temperament exist between cat breeds (Duffy et al., 2017; Salonen et al., 2019; Takeuchi & Mori, 2009; Wilhelmy et al., 2016) and it is possible this translates into different breeds having different management and care needs. Research suggests that owners of pedigree cats may research any breed-specific traits or requirements (Martos Martinez-Caja et al., 2021). However, for owners unsure of pedigree status researching any breed-specific traits may be difficult, thus the care of these animals may be less tailored to their needs than for pedigree cats.

A reporting bias may exist for pedigree cats, as opposed to unknown cats, wherein owners under-report problem behaviours. Packer et al. (2012) suggest medical concerns that are common for certain breeds of dog are often not viewed as a cause for concern by the owners, but rather as 'normal for the breed'. Owners of known pedigree cats may also view certain behaviours as 'normal for the breed', causing owners to become desensitised to the behaviour's impact/frequency. Indeed, Martos Martinez-Caja et al. (2021) suggest that many behaviours often deemed to be problematic by cat owners, for example vocalisation or fear responses, were not found to be problematic to owners of Bengal cats. It is important for owners to understand if their cat requires specific care or if they are likely to express problem

behaviours at a higher rate than other breeds or non-pedigree cats. This will likely improve management and provision and hence in-home welfare; it may also reduce the likelihood of relinquishment on behavioural grounds.

#### *AREA TYPE*

This study indicates that location is important for cats with indoor-outdoor lifestyles, but not for indoor-only cats. Owner-reported problem behaviours decreased as areas moved from urban to rural (e.g. city centre, urban, suburban, village and rural). This may be due to a reporting-bias by owners, if owners in rural areas are typically older and more accustomed to living with animals thus more tolerant of such behaviours. It also may suggest that the quality of the outdoor environment is important in the development of problem behaviours. In rural areas, there is likely less territorial competition, more hunting opportunities and fewer stressors than in a city environment. In cities, a higher density of cats may lead to greater conflict, and loud, dynamic environments in the way of cars, people and noise may contribute towards stress (Bradshaw, 2013). It has also been suggested that interactions with conspecifics may increase territorial marking behaviours within the home (Little, 2016), which may impact urban cats more frequently than rural cats.

It is also possible that outdoor urban environments are naturally less complex than rural areas. For example, rural gardens may provide an abundance of green spaces in which to hide, greater numbers of prey animals to stalk or hunt, natural water sources, toileting spots and trees to climb, scratch or mark. Urban spaces may be more homogenous and host less wildlife, thus not providing the same degree of variation and therefore opportunity. Some of these problem behaviours may be mitigated if owners of cats in urban environments provide additional outdoor enrichment such as hiding spots, scratching spots and outdoor food or water sources. Although outside the scope of this paper, even when given the opportunity many cats choose not to venture outdoors (as seen in Foreman-Worsley et al. 2021: Chapter 3), and it may be that the quality of the outdoor environment plays a role in this choice for cats. Overall, further study into the quality of outdoor environments for cats is warranted.

### *AVAILABLE ROOMS*

Decreasing problem behaviour scores were associated with increasing room numbers in indoor-only cats. Available space and cat density have previously been linked to cat wellbeing and/or problem behaviours, although many studies have been based in shelters, catteries and research labs, rather than the domestic home (Kessler & Turner, 1999; Lichtsteiner & Turner, 2008). In environments other than the home, it has been postulated that additional space represents the opportunity to escape unwanted social interactions, which may also be applicable to a domestic setting. Additional space may also offer quiet reprieve from noise and electronic devices that can be aversive to the sensitive hearing of a cat (Crawford et al., 2018). For indoor-only cats in particular, access to a greater number of rooms likely represents a relatively large increase in available living space, given that flat/apartment living is associated with provision of indoor-only lifestyles for cats (Foreman-Worsley et al., 2021; Johnson et al., 2017; Tan et al., 2021), and this type of accommodation typically has a relatively small footprint. Additional living space will facilitate further enrichment in the form of sights, smells and furniture that can help towards fulfilling behavioural needs, such as wardrobes to climb, beds to hide under, or soft chairs for resting. Extra rooms may also enable more cat-friendly resource distribution, allowing litter trays to be placed in quiet spots away from food or water sources (Tomlinson, 2016). Cats are also afforded more control over their proximity to humans, conspecifics or other animals. Access to a greater number of rooms may not significantly impact problem behaviour scores in cats with outdoor access, as outdoor space and natural enrichments supersede the benefits of additional space and enrichment within the home.

### *SOCIAL ENVIRONMENT*

For both forms of outdoor access, increasing social scores were significantly correlated with decreasing problem behaviour scores. An increased social score may represent more opportunities for positive social interactions and caretaking, which would correlate with the higher social scores seen in cats with unrestricted indoor-outdoor lifestyles compared to indoor-only and managed indoor-outdoor lifestyles. As seen in table 17, more interaction with owners (Heidenberger, 1997), longer playtime bouts (Strickler & Shull, 2014) and living in a multi-cat household (Amat et al., 2009; Schubnel & Arpaillange, 2008; Yamada et al., 2020) have been shown to correlate with decreased problem behaviours, and greater time alone, no

children, single owners or couple family dynamics (Heidenberger, 1997) and less interaction with people (Tamimi et al., 2015) correlate with increased problem behaviours. In cats with some form of outdoor access, this may act as an important refuge for cats to remove themselves from social interaction with humans, cats or dogs within the household. The ability to avoid social interaction when it is unwanted may prevent frustration or aggression, relatively common problem behaviours, and enable individuals to benefit from these interactions when desired. Indeed, owners have been cited to provide outdoor access with the specific consideration of allowing their cat to avoid conspecifics (Foreman-Worsley et al., 2021: Chapter 3).

#### *HOURS ALONE*

In unrestricted indoor-outdoor cats, increased time alone without people was associated with an increased problem behaviour score. Both de Souza Machado et al. (2020b) and Heidenberger (1997) concurred, with greater time spent alone being associated with more problem behaviours, specifically anxious behaviour. One may speculate upon the reason for this in unrestricted indoor-outdoor cats, as mentioned previously, interaction with people may be a mitigator of problem behaviours (Heidenberger, 1997; Tamimi et al., 2015). Owners of outdoor cats may operate under the assumption that the outdoor environment is inherently enriching for their cat. They may therefore feel more comfortable leaving their cat alone for longer periods or be less inclined to interact with their cat deliberately, e.g. by playing, an activity that has been shown to decrease problem behaviours as play bouts increase (Strickler and Shull, 2014). Little research has been conducted into differences between play between cats with different lifestyles. However, de Souza Machado et al. (2020b) found more owners of indoor-outdoor cats report never playing with their cat than owners of indoor-only cats. Likewise, outdoor cat owners were less likely to groom their cat or buy them gifts and toys. Tan et al. (2021) report that owners of cats with uncontrolled outdoor access spend less time actively playing with their cat, and less time training their cat. The sentiments that the outdoors may compensate for cat-owner interaction echo those seen for enrichment provisions. Thus, alongside enrichment recommendations for all cats irrespective of lifestyle, it is important to highlight to owners of cats with outdoor access that positive interactions with their cat are still important, and that may help to reduce problem behaviours.

## *ENRICHMENT*

Results from the indoor-only model suggest enrichment may be an important mitigator of problem behaviour in indoor-only cats, as decreasing problem behaviour scores were seen as enrichment scores increased. Previous literature has demonstrated links between environmental provisions and problem behaviours (de Souza Machado et al., 2020a; Lawson et al., 2019; Mengoli et al., 2013; Strickler & Shull, 2014) and, as discussed earlier, provision of enrichment is often recommended by many charities and welfare professional. This study is one of the first to indicate a cumulative effect of enrichment, due to its utilisation of enrichment composite scores.

Conversely, in cats with unrestricted indoor-outdoor access, increasing enrichment scores correlated with increasing problem behaviour scores. This could be indicative of a reactionary approach to enrichment, whereby owners of cats who display problem behaviours provide items in a bid to mitigate those behaviours, in contrast to indoor-only owners provide items of enrichment proactively as they see as it necessary from the start. For example, fewer unrestricted indoor-outdoor cat owners provided a litter tray compared to indoor-only or managed indoor-outdoor owners. Outdoor cat owners providing a litter tray might be doing so as their cat displays problem behaviours such as inappropriate elimination or spraying behaviour. Yet as these behaviours could be linked to territorial behaviour exacerbated by contact with neighbourhood cats, the presence of the litter tray may not mitigate the problem behaviours. Consequently, we see cats with higher problem behaviour scores, who also have higher enrichment scores.

### 4.5. LIMITATIONS

In this study, the problem behaviours used within the composite scales were those reported to be most problematic to owners within the currently available literature, however it is important to remember that additional behaviours deemed to be problematic by owners may occur, albeit at lower rates. Additionally, problem behaviours only relevant to sub-populations of cats were not included within the survey, as the study was designed to ensure comparability of problem behaviour scores of cats living in different environments. For example, problem behaviours exhibited by outdoor cats which were not captured in this survey may include

hunting, fighting with neighbouring cats or eliminating in gardens, or cats within multi-cat households may exhibit aggression towards one another.

The nature of the composite scores does mean it is not possible to analyse each problem behaviour individually to identify causation. However, insight has been gained into potential influencing factors for increased or decreased levels of specific owner-reported problem behaviours, as detailed throughout the discussion with regards to spraying behaviours or inappropriate elimination for example. To investigate these specific behaviours in more detail it is likely to be most valuable to design specific studies with targeted research questions, using larger, broader studies like this as a starting point for deciding the plausible explanatory variables for inclusion, as well as identifying where new explanatory variables, e.g. olfactory cues, could be included. For some behaviours it is possible that a reporting bias exists for owners of cats with different lifestyles. Owners of indoor-only cats are likely to spend more time in proximity to their cat, and so may be more likely to observe behaviours such as excessive vocalisation or hiding at unexpected noises. Additionally, for owners of indoor-outdoor cats who toilet outside, they may be less likely to observe behaviours such as diarrhoea and constipation than owners who clean litter trays daily and can more closely monitor their cat's toileting habits. Despite these limitations, as the focus of this study was to assess how environment and lifestyle may impact behaviour as it is interpreted by owners, this bias was deemed to be acceptable. It may be assumed that owners who do not witness such behaviours do not find them problematic.

Finally, as discussed within the introduction, current issues within the literature include cats with different lifestyle being grouped together for analysis e.g. cats with completely unrestricted outdoor access being classed as 'outdoor', alongside cats who are taken out every few days on a leash, or those who have their movement restricted by catios. Whilst it was not possible in this study to analyse each individual level of restriction due to low sample numbers, by grouping subjects into managed and unrestricted indoor-outdoor access this is one of the first studies to comprehensively demonstrate significant differences in both behaviour and environment may exist between cats with differing levels of outdoor access. This highlights that is therefore valuable for future studies to carefully consider grouping of cats with differing levels of outdoor access, and that all levels of outdoor access need to be studied in more detail.

#### 4.6. FURTHER RESEARCH

Whilst this study represents how lifestyle and environmental differences may impact owner-reported problem behaviours, it would be beneficial to understand how these differences may impact the wellbeing of the cats themselves. Utilising owner interpretation of problem behaviours and their frequency could be more indicative of owner tolerance levels and the current state of the cat-owner bond, rather than of any stress the cat may be experiencing. Therefore more robust measurements of feline stress are needed outside of behavioural observation. These measurements may be found through physiological data, such as cortisol, which is a hormone released in response to exogenous or endogenous stressors (Burke et al., 2005; Palme, 2012; Stalder & Kirschbaum, 2012). Cortisol may give indication as to which environmental variables are the greatest perceived stressors by cats and help us to triangulate physiological stress with reported problem behaviours, to give insight as to whether the problem behaviours we are measuring can be used as a proxy measure of cat wellbeing.

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CHAPTER FIVE: AN  
EXPLORATION OF FACTORS  
AFFECTING EXPRESSION OF  
CORTISOL IN THE HAIR OF  
DOMESTIC CATS (*FELIS CATUS*)

## 1. INTRODUCTION

Using proxy measures to make inferences concerning the welfare of domestic animals within our care is important. Traditionally, behavioural observations have been used, yet more recently, physiological measures are being utilised to infer welfare. Cortisol has been employed to investigate stress across many species, including humans (Burke et al., 2005; Cook et al., 2012; Palme, 2012; Stalder et al., 2017). Cortisol is a hormone released by the hypothalamic-pituitary-adrenal (HPA) axis in response to perceived positive or negative stressors, either exogenous (internal) or endogenous (external), and physiological or psychological. Upregulation of cortisol production in response to negative stressors aids individuals in the management of stress via regulation of metabolism and increased energy, control of blood pressure or reduced inflammation (Hoehn & Marieb, 2010; Ando et al., 2021). Chronic stress may see consistently elevated cortisol levels lead to depressed or anxious states and decreased immune function, increasing susceptibility to disease and further reducing welfare (Broom, 1993; Moberg & Mench, 2000).

Cortisol can be measured in blood, saliva, faeces, urine or hair (Hoehn & Marieb, 2010). Some provide measurements of short-term and rapidly changing cortisol concentrations, such as blood and saliva (Heimbürge et al., 2019). These cortisol sources are therefore useful for measuring physiological responses to an acute stressor. However, some collection methods (e.g. blood samples) are invasive and can be exogenous stressors within themselves, thus confounding results (Sheriff et al., 2011). For measuring long-term cortisol levels, hair is increasingly being used, despite the underlying mechanisms of hair cortisol incorporation into the hair shaft having not yet been fully elucidated. Meyer and Novak (2012) suggest that circulatory cortisol within the bloodstream is incorporated into the hair shaft during the growth phase. Due to the incorporation of cortisol into the hair over many weeks, it is thought that hair cortisol concentration (HCC) can provide an insight into the average stressors an individual may be experiencing over a mid to long-term period (Gow et al., 2010; Heimbürge et al., 2019). This feature makes HCC particularly useful in measuring overall environmental stressors and subsequent inference of welfare state. Hair has additional benefits compared to blood, urine or faeces, in that collection methods are relatively non-invasive, hair is easier to transport and store and it is less likely to be a biological hazard (Russell et. al., 2011).

The potential of HCC to provide insight into long-term stressors has seen it utilised across welfare studies in companion animal species (Grigg et al., 2017; Packer et al., 2019), farm animals (Comin et al., 2011; Sharma et al., 2019), zoo animals (Carlitz et al., 2014; Salas et al., 2016) and wild animals (Fourie et al., 2015; Macbeth et al., 2010, 2012). Such studies have provided evidence that HCC may be influenced by many exogenous factors, such as housing (Comin et al., 2011; Grigg et al., 2017) and social environment (Casal et al., 2017; Roth et al., 2016). In addition to exogenous stressors, endogenous factors such as sex (Azevedo et al., 2019), age (Santymire et al., 2021) and temperament (Finkler and Terkel, 2010) may also influence hair cortisol levels.

Studies in cats are currently limited, however those that exist suggest both exogenous and endogenous factors may influence measured HCC. Contreras et al. (2021) demonstrated coat condition and litterbox issues (defined as urination or defecation outside of the litterbox) correlate with HCC. Cats with good coat condition (described as 'groomed' by the authors) and cats without litterbox issues were found to have lower HCC than cats without groomed coats or with litterbox issues. Contreras et al. (2021) also suggest the importance of sampling region, finding poor HCC agreement in samples from the dorsal neck and lumbosacral area, and moderate agreement between the dorsal neck and abdomen. Sample sizes for this comparison were, however, small (n=19). Factors reported to have no significant impact on HCC include sex, coat colour and neuter status. Zijlstra (2017) agreed, finding sampling region was important, but sex, coat colour and neuter status had no impact on HCC. Additionally, Zijlstra (2017) report breed type and age may have a small but significant impact on HCC, given the low correlation coefficient for these variables. Contrary to these published studies, Finkler and Terkel (2010) found neutered females had lower HCC than intact females, and that HCC in intact females positively correlated with agonistic behaviours. In their subsequent study, evidence suggested that in intact females, more dominant individuals had higher HCC (Finkler and Terkel, 2015). Finkler and Terkel (2010) suggested many of the females in the free-roaming population studied may have been pregnant, lactating or in oestrus, which may cause the elevated HCC, rather than neuter status itself.

Feline studies utilising cortisol sources other than hair (e.g. faecal, urinary) found many factors that are associated with changes in cortisol levels, a large majority of

them pertaining to social environment (see appendix 1,2, and table 4,5,6 for full details). These included human density, number of people in the household and space available per cat (Lichtsteiner & Turner, 2008), higher owner social scores (Ramos et al., 2012), age and tolerance of petting by humans (Ramos et al., 2013), unpredictable or stressful caretaking schedules and hiding behaviour (Carlstead et al., 1993), sickness (Henry et al., 1996; McCobb et al., 2005) and environmental enrichment and exposure to dogs (McCobb et al., 2005). Accorsi et al. (2008) explored cat HCC in a feasibility capacity and demonstrated that cortisol levels in cat faeces appear to be positively correlated with HCC levels. It is therefore reasonable to assume that cat HCC may also correlate with a range of social and environmental factors.

As discussed in Chapter 4, it is unclear how reliable owner reports of sickness and undesirable behaviours (hereafter referred to as ‘problem behaviours’ as described in Chapter 4) are. Factors such as time spent out of sight of owner, varying owner tolerance of problem behaviours and incidences of problem behaviours taking place outdoors (e.g. vomiting or diarrhoea) may go unreported. Additionally, owners may not recognise certain problem behaviours as indicative of stress or illness (Mariti et al., 2017). If physiological measures such as cortisol could be triangulated with behavioural indicators, we may better understand if owner-reports of behaviour can be associated with wellbeing. Additionally, HCC may give us insight into which, if any, environmental variables contribute towards perceived stress in owned cats. This knowledge could better inform all stakeholders of which environmental factors may cause stress to cats. Subsequently, guidance on enrichment and changes within the home to improve welfare and the owner-animal bond could be provided.

### 1.1. AIMS AND OBJECTIVES

The aim of this study is to investigate whether environmental or demographic variables that may impact the welfare of domestic cats can be linked to a physiological measure of stress i.e. long-term cortisol production, and whether long-term cortisol production is associated with owner-reported features relevant to their cat’s wellbeing and experiences, such as problem behaviours.

This will be completed by:

- Assessing whether differing levels of mean hair cortisol concentrations are found between different subpopulations of owned domestic cats
- Investigating whether there are any correlations between HCC and problem behaviour scores
- Exploring whether environmental or demographic variables that predict problem behaviour score also predict HCC levels

## 2. METHODS

### 2.1. SURVEY CREATION AND DISTRIBUTION

As detailed in Chapters 3 and 4, an online survey was created using Jisc Online Surveys ([onlinesurveys.ac.uk](http://onlinesurveys.ac.uk)) for current cat owners (see appendix A3). In addition, owners had the option of partaking in part two of the study. Part two requested that survey participants send in a small fur sample from their cat to be analysed for its cortisol content. Participants were instructed, using an image for guidance (figure 6), to cut or shave a pinch of hair from the thigh/hip (ischiatric) region of their cat (Accorsi et al., 2008). The hair was to be removed as close to the skin as possible, avoiding any risk to the animal. Hair was bagged or wrapped in clingfilm/tin foil and sent to the author in an envelope. As the survey responses were anonymous, identifying codes were generated by using the first half of the owner's postcode, followed by the first three letters of their cat's name, followed by the last two digits of their phone number. Owners were instructed to include these codes with their sample to ensure hair samples and HCC could be matched with the appropriate survey data. Once received, samples were stored in the dark at room temperature until the start of processing, as cortisol has previously been shown to be stable in fur for up to two years (Yamanashi et al., 2016). Ethical approval was granted on the 11<sup>th</sup> December 2018 by Nottingham Trent University School of Animal, Rural and Environmental Sciences Research and Ethics Committee (ARE843).

**Figure 6, Image provided to owners to indicate where to cut their cat's hair sample from:** The image provided with the online survey highlighting the ischiatic region of the cat, to guide hair sampling.



## 2.2. DATA PROCESSING

As detailed in Chapter 3, cats were grouped into life stages for analysis. The composite scores for behaviour, enrichment and social environment, as detailed in Chapter 4, were again utilised within this study.

### 2.2.1. SAMPLE EXCLUSION

174 usable samples were taken forward for processing after sample exclusion. Cats shampooed as part of a grooming routine, no matter how infrequently, were excluded as studies have suggested such processes strip cortisol from hair samples (n=1; Hamel et al., 2011). Any cats detailed to have ongoing medical conditions were excluded before analysis, on the basis that sickness and disease has been suggested to increase levels of cortisol in cats (Henry et al., 1996; McCobb et al., 2005), and these may confound the effects of the external environment. One cat within the population was unneutered, and one owner was unsure of neuter status, so these individuals were excluded on the basis that neuter status may impact cortisol (Finkler and Terkel, 2010, 2015) but this was not a factor that could be controlled for in the analysis due to the small sample size. As detailed in Chapter 4, cats were also excluded if there were 6 or more cats in total within the household (n=8).

## 2.3. HAIR PROCESSING

Methods were adapted from previous studies (e.g. Agnew et al., 2016; Packer et al., 2019). At present, there are no validated methods for the assessment of cat hair cortisol, nor do any hair cortisol test kits exist. Thus, to enable results to be as

comparable as possible to those in other studies, methodologies were kept as similar to other studies as possible, whilst accounting for differences in equipment or hair texture and density. Hair samples were roughly cut into 1-2mm pieces using scissors cleaned between samples using 99% isopropyl alcohol. Approximately 50mg of hair was placed into a 2ml Eppendorf tube with a 5mm ball bearing. Hair was powdered in a ball mill for 15 minutes at 30Hz and transferred to a glass bijoux. A 2ml aliquot of methanol was placed into each glass bijoux for incubation overnight at 37°C. The next day, 1.5ml of methanol solution was transferred to a 1.5ml Eppendorf tube where it was centrifuged for 2 minutes at 13,000RPM. The supernatant was removed and dried in 1.5ml Eppendorf tubes in a speedvac at 50°C for 2 hours. Dehydrated samples were stored at -20°C before assaying. As for other studies, and due to no specific hair cortisol kits being commercially available, a Salivary Cortisol kit (Salimetrics, Newmarket) was used to determine the cortisol concentration for each sample as per the manufacturer's instructions. Resulting HCC values were expressed in mg dl<sup>-1</sup>, normalised per milligram of hair. The intra-assay coefficient of variance (CV) was 2.0%, whilst the inter-assay CV (i.e. the variance between plates) was 14.7%.

#### 2.4. DATA ANALYSIS

IBM SPSS (Version 26, New York, NY, USA) was used for all data analysis. Data exploration through Shapiro-Wilk tests and histograms indicated HCC data were non-normally distributed. Thus, Mann-Whitney U and Kruskal-Wallis tests were utilised to ascertain if significant differences existed between the mean HCC levels of different categorical variables e.g. lifestyle, cat sex. Spearman correlations were used to identify if HCC was correlated with the problem behaviour composite. A significance threshold of  $p < 0.05$  was used. Additionally, a generalised linear model (GLM) was conducted utilising previous explanatory variables (i.e. cat sex, life stage, pedigree status, area type, rooms the cat had access to within the home, enrichment composite score, social composite score and hours left alone without people per day as in Chapter 4). Lifestyle was also included as an explanatory variable, having been previously identified as significant (Chapter 4). Additionally, hair length was included, to see if these variables could collectively predict HCC as an outcome variable. The aim of the model was to test whether different variables deemed to be of potential biological relevance to HCC impacted the levels of HCC significantly, and so all variables were included in the model, rather than



completing a stepwise or iterative process to find the model that best explained HCC levels. As the dependant variable (HCC) was continuous in nature, all values were positive and the distribution had a positive skew due to a small quantity of high data points, a Gamma regression with a log-link function was chosen over a linear regression (Simon Moss, n.d.).

#### 2.4.1. OUTLIERS

Initial data exploration of normalised HCC with regards to distribution indicated that potential outliers may exist within the data set. In total, 5 samples were identified as outliers, and an additional 12 samples were identified as extreme outliers by the 'Explore' function within SPSS, which utilises Tukey's method and box and whisker plots to identify outliers. All outliers were on the high end of the scale. These data points were examined for obvious issues that may explain their identification as outliers. No issues with input or calculation errors could be detected. No additional comments with regards to sample abnormalities, medical conditions or recent treatments were found within initial survey submissions. As it was not thought that these values had been created as the result of an error, and considering that physiological data exists on a scale, it was deemed possible that these readings represent individuals with genuinely raised cortisol levels and the decision to leave these data points in throughout the subsequent analyses was taken.

### 3. RESULTS

#### 3.1. DEMOGRAPHICS

In total, 174 HCC samples were included in the analysis. Sex ratio was exactly 1:1 (both n=87). Adult cats accounted for the largest age category at 33.3% (n=58), followed by junior cats at 27% (n=47) and mature cats at 21.3% (n=37), finally senior cats were the fewest at 18.4% (n=32). Most cats were not pedigree (85.1%, n=148), although 2.3% (n=4) of owners were unsure. With regards to lifestyle, 33.3% (n=58) were indoor-only, 39.1% (n=68) had managed indoor-outdoor access, and 27.6% (n=48) had an unrestricted indoor-outdoor lifestyle. No cats within this study were declawed. As detailed in 2.1.2., all cats were neutered, and no cats were reported to have ongoing medical conditions.

### 3.1.1. COMPOSITE SCORES

The composite scales created in Chapter 4 were used within the analysis. A breakdown of the descriptive statistics for range, mean, standard deviation (SD) and variance for each composite measure can be seen in table 24.

**Table 24, Descriptive statistics for composite scores:** Descriptive statistics for the composite scores included within the analysis.

Composite	Possible range	Displayed range	Mean	Standard Error of Mean	Standard Deviation	Variance
Problem behaviour	0-33	0-10	2.90	0.17	2.23	4.97
Enrichment	0-6	1-6	4.90	0.10	1.29	1.67
Social	0-4	0-4	1.57	0.07	0.90	0.81

### 3.2. HAIR CORTISOL

No significant correlation was found between HCC and problem behaviour score ( $r_s=0.075$ ,  $p=0.323$ ).

#### 3.2.1. GENERALISED LINEAR MODELS

The variables used as predictors of problem behaviour score in the GLMs in Chapter 4, with the inclusion of lifestyle and hair length, were found to produce a model significant in predicting HCC based on the results of the omnibus test (Likelihood Ratio Chi-Square=154.911,  $p<0.001$ ). Within the model, five variables were found to have an impact on HCC levels (table 25). Life stage impacted HCC (Wald chi-square=19.397,  $p<0.001$ ), with junior cats found to have higher HCC readings than adult cats ( $p<0.001$ ,  $\text{Exp(B)}=2.196$ , 95% CI=1.470-3.281). Lifestyle (Wald chi-square=25.204,  $p<0.001$ ) showed that indoor-only cats had higher HCC readings than managed indoor-outdoor cats ( $p<0.001$ ,  $\text{Exp(B)}=0.405$ , 95% CI=0.276-0.593) and unrestricted indoor-outdoor cats ( $p<0.001$ ,  $\text{Exp(B)}=0.394$ , 95% CI=0.256-0.606). Area type was found to be significant (Wald chi-square=13.022,  $p=0.011$ ), with village ( $p=0.006$ ,  $\text{Exp(B)}=2.589$ , 95% CI=1.391-5.079) and rural ( $p=0.026$ ,  $\text{Exp(B)}=2.573$ , 95% CI=1.122-5.904) environments showing higher HCC readings than the city centre. Finally, as the number of rooms the cat had access to increased, so did HCC (Wald chi-square=6.995,  $p=0.008$ ,  $\text{Exp(B)}=1.096$ , 95%

CI=1.024-1.173). Cats with long hair had lower HCC readings than cats with short hair (Wald chi-square=24.814,  $p < 0.001$ ,  $\text{Exp}(B)=2.199$ , 95% CI=1.468-3.295).

HCC was not significantly associated with cat sex ( $p=0.312$ ), pedigree status ( $p=0.964$ ), enrichment composite scores ( $p=0.381$ ), social composite scores ( $p=0.429$ ) and the daily number of hours a cat was left alone without people ( $p=0.144$ ).

**Table 25, GLM results of variables that predict hair cortisol concentration:** The results from the GLM exploring whether HCC could be explained by the factors identified in the literature as having a significant impact on problem behaviour (detailed thoroughly in Chapter 4).

Variable	Wald Chi-Square	df	Significance
CatSex	1.023	1	0.312
Life stage	19.397	3	<0.001
Pedigree	0.074	2	0.964
Lifestyle	25.204	2	<0.001
AreaType	13.022	4	0.011
RoomAccess	6.995	1	0.008
EnrichComp	0.768	1	0.381
SocialComp	0.626	1	0.429
HoursAlone	2.130	1	0.144
CoatLength	24.814	2	<0.001

## 4. DISCUSSION

### *LIFESTYLE*

Indoor-only cats had significantly higher HCC levels than cats with managed or unrestricted indoor-outdoor lifestyles. Housing has been shown to impact HCC levels in a range of species, including horses (Mazzola et al., 2021) and cows (Comin et al., 2011; Sharma et al., 2019), and impact cortisol levels measured in blood (Parker et al., 2021; Schumann et al., 2014), urine (Kamakura et al., 2016) and saliva (d'Angelo et al., 2021). These studies suggest that housing that is more stressful produces higher HCC levels than lower-stress environments, with more intensive systems, housing with no enrichment that reduces the capacity for free-will and

housing that does not facilitate behavioural needs producing higher HCC levels. Consequently, that indoor-only housing correlates with higher HCC in owned, domestic cats warrants further research to explore the exact components that are resulting in this difference, and if it is a welfare concern. It is possible that indoor-only cats are less able to escape unwanted interaction with conspecific, dogs or owners than those with outdoor access, which may represent an exogenous stressor. However it must be noted that social composite scores had no correlation with HCC in the models produced, potentially due to the measure not being sufficiently granular and the individual stressors within the composite being treated as heterogenous. An indoor-only environment may also offer fewer opportunities to carry out behavioural needs such as roaming, patrolling, marking of territories or hunting than outdoor lifestyles, as discussed in Chapter 4, where problem behaviours were found to be higher in indoor-only cats.

Conversely, the higher HCC levels seen may be due to higher levels of positive arousal. Packer et al. (2020) demonstrate that dogs who engage in competitive fly ball have higher levels of HCC than those who don't. Souza Machado et al. (2020b) demonstrate that slightly more owners of indoor-only cats play with their cats than owners of cats who have outdoor access, and as seen in chapter 4, indoor-only cats are typically provided with more toys than cats with outdoor access. The potential impact of positive arousal in cats to increase HCC is therefore worthy of further exploration.

The type of cats likely to be provided with specific lifestyles may also impact the differences in HCC. Younger cats are more likely to be indoor-only (Foreman-Worsley et al., 2021: Chapter 3), and we see that juveniles in this study were more likely to have higher HCC than adult cats. We also see pedigree cats are more likely to have higher HCC scores than non-pedigree cats, and that pedigree cats are more likely to be kept as indoor-only (Foreman-Worsley et al., 2021: Chapter 3).

Finally, it must be considered that light and UV bleaching, which has been shown to diminish the measurable levels of HCC in the hair of cattle and pigs (Otten et al., 2021) and humans (Wester et al., 2016), may be more prevalent in cats with outdoor access. However, in cats with managed indoor-outdoor access, which includes restricted lifestyles such as confinement to catios or summer houses, and cats that likely access the outdoors with less frequency than cats who have

unrestricted outdoor access, you may not expect to see differing HCC levels compared to indoor-only cats if light bleaching played a major role in this difference. For clarity, further study into any correlation between HCC and the number of hours spent outdoors, with considerations such as season and sunlight hours included, is warranted.

#### *BEHAVIOUR SCORE*

HCC levels were not found to be significantly correlated with problem behaviour composite scores, suggesting that HCC is not a suitable mechanism to assess any welfare implications of problem behaviours at this level of granularity. Other limited literature that exists for HCC in cats has shown a similar lack of correlation (Contreras et al., 2021). Consequently, HCC studies in cats may be better suited to assessing the impact of large environmental changes on welfare, for example cattery stays, rehoming, moving house, or the addition of dogs, cats or babies into the household. Studies in other species have demonstrated significantly higher HCC in several species post-relocation to new housing (Davenport et al., 2008; Gardela et al., 2020; Peric et al., 2016). In these types of study, shave-reshave methods may prove to be useful in determining if HCC levels post-change are measurably different to the baseline of the individual beforehand (Davenport et al., 2008; Heimbürge et al., 2020).

There is some possibility that this sample of cats did not have high enough problem behaviour scores to see any correlation with HCC. The possible range for the problem behaviour score, which considers both the number of different problem behaviours exhibited and their frequency, is between zero and 33. However, within the cats in this study the maximum problem behaviour score seen was ten, which indicates these cats do not have particularly problematic behaviours. Such low scores may not be sufficient for detecting correlations with HCC, but cats with higher prevalence or frequency of problem behaviours might see correlations with HCC. Owned cats with higher scores may be missing from this study as cats with more severe behavioural issues may be relinquished for rehoming (Jensen et al., 2020; Salman et al., 1998). Owners may also seek veterinary advice for behavioural issues. In this study all cats with medical issues were excluded before analysis, irrespective of the specific condition listed by the owner, as no veterinary data was provided to validate conditions reported. This included cats detailed as being anxious individuals, or those diagnosed with stress or stress-related symptoms.

Cats with known anxiety or stress-related behaviours may display higher problem behaviour scores and may also be more likely to display higher HCC. However, it must be noted that Mougeot et al. (2017) found no differences in the baseline levels of HCC between apparently healthy cats, and those suffering from feline idiopathic cystitis (FIC), a condition thought to be correlated with stress in cats (Cameron et al., 2004; Buffington and Bain, 2020). Nevertheless, assessing correlations between HCC and problem behaviour scores on the higher end of the scale would be ideal to elucidate if no trend is present at all, or to ascertain whether the absence of correlation within this study was due to cats displaying a limited range and/or severity of problem behaviours.

Changes to the behaviours utilised within the composite may produce different results. As detailed in Chapter 4, the problem behaviour score utilises behaviours typically deemed to be problematic by owners, not behaviours problematic from the perspective of the cat. For example, scratching is a behaviour within a cat's natural repertoire, however when directed towards furniture, owners are likely to view this as problematic as they do not want to see their goods destroyed. Thus the measurement of this behaviour likely does not provide insight into the wellbeing of the cat, although it may reflect insufficiencies within the cat's management. A different composite score solely comprised of sickness behaviours such as diarrhoea and vomiting, symptoms thought to be associated with stress in cats (Stella et al., 2013), may see correlation with HCC as demonstrated by Contreras et al. (2021), who found higher HCC levels in cats with litterbox issues (in this instance described as urinating or defecating outside of the litterbox).

It is also possible that completion of the behaviours measured help to mitigate stress as they are performed. For example, overgrooming is a repetitive behaviour that may cause trauma in the form of hair loss or skin damage to the area which it is directed (Titeux et al., 2018). Whilst this trauma is a welfare concern that requires monitoring and treating, the act of repetitive overgrooming may be a coping mechanism which ultimately helps the cat to deal with negative situations. Grooming behaviours have been posited as a self-soothing behaviour and have been observed at a higher frequency after conflict (van den Bos, 1998). Abnormal repetitive behaviours (ARBs), sometimes referred to as stereotypies are repetitive, invariant behaviour patterns with no obvious goal or function (Mason, 1991). ARBs have been documented in many species across a range of settings, for example pigs

on farms (Arellano et al., 1992), polar bears in zoos (Shepherdson et al., 2013) and rhesus macaques in laboratories (Poirier & Bateson, 2017), and are thought to be a mechanism that facilitates an animal to cope with their environment. Research into associations between stereotypies and cortisol levels in other species is currently inconclusive. Many studies have found no differences in cortisol between animals displaying repetitive behaviours and those not (Fureix et al., 2013; Pell & McGreevy, 1999; Webb et al., 2016), whilst others show higher cortisol is measured in animals displaying stereotypies (Malmkvist et al., 2011; Qin et al., 2020) and also that behaviours indicative of poor welfare correlate with lower cortisol levels (Pawluski et al., 2017; Shepardson et al., 2004; Zealand et al., 2013), potentially due to the behaviour acting as a coping mechanism, or alternatively due to chronic stress and depressive states. Disparity in the currently available literature may arise due to differences in the substrate the cortisol is measured in, the length of time the animal has been performing the behaviour or the type of behaviour being performed, or the context in which the behaviour is being performed e.g. at times of arousal or at times of under stimulation (Denham et al., 2016). Whilst ARBs were not specifically documented in this study, it is possible that some of the cats may have exhibited behaviours such as grooming with enough frequency to meet the diagnostic criteria for overgrooming. In general, more research into ARBs and potential effect on cortisol levels is warranted, especially in the instance of domestic cats where links between behaviour and cortisol have not yet been explored substantially.

#### *HAIR LENGTH*

In this study, cats with long hair had lower HCC scores than those with short hair, and hair length was a significant variable in the model predicting HCC. These results contrast with Contreras et al. (2021), who found no correlation between HCC and hair length. However, Contreras et al. (2021) did find cats with groomed coats had lower HCC values than cats without groomed coats. Coat condition has been suggested to be an overall welfare indicator (Bowen & Heath, 2005), with decreased grooming thought to be associated with depressive states or pain (Battersea, n.d.) and overgrooming a dysregulated self-soothing response to distress (Titeux et al., 2018). Poor coat condition may be more obvious in long hair cats, meaning owners can more readily react to suboptimal living conditions or seek veterinary assistance sooner than for cats with medium or short coats, lowering

overall levels of HCC. Grooming by owners may also be undertaken more often for cats with long hair, which may introduce a confounding factor with the effect of social interaction on HCC, but also mean owners are more likely to notice poor coat condition. Additionally, it is possible that cats with long hair may groom themselves more frequently than those with medium or short hair, which may lead to a wash-out effect (Acker et al., 2018). The impacts of grooming on HCC levels are not yet fully understood, although it is possible that it may contribute towards the differing levels of HCC seen in hair samples taken from different body regions (Contreras et al., 2021; Terwissen et al., 2013).

Hair length may also be related to pedigree status. Pedigree cats are often bred for their unique appearances and many breeds, for example Ragdoll, Maine Coon or Persian cats, have long hair. Brief analysis of this data set suggests that a higher portion of pedigree cats had long hair than non-pedigree, with a chi square test suggesting these differences were statistically significant ( $\chi^2=10.321$ ,  $p=0.006$ ). It is possible that owners of pedigree cats are more attentive to their care and more reactive to any indication that welfare might be compromised, given the often large financial costs of obtaining a pedigree animal.

Finally, uneven distribution of cortisol throughout the shaft of the hair may contribute. Other studies have suggested that the distal hair end may have lower HCC concentrations than proximal hair ends (Carlitz et al., 2015; Duran et al., 2017), and this effect may be more obvious in longer hair. It must be noted, however, that many studies have found no differences in HCC concentrations between hair ends (Bennett & Hayssen, 2010; Davenport et al., 2006; Macbeth et al., 2010), and a rare few have found distal hair segments with higher HCC values (Heimbürge et al., 2020). Further investigation into the impact of hair length on any segmental distribution of HCC along a hair shaft in cats is therefore warranted, to allow future studies to control for these variables.

#### *LIFE STAGE*

Junior cats were found to have higher levels of HCC than adult cats. Junior cats may be exposed to more frequent stressful life events than cats of adult age, in the form of rehoming which has been demonstrated to correlate with increased HCC in other species (Davenport et al., 2008; Gardela et al., 2020; Peric et al., 2016) or multiple veterinary visits and surgeries (Creutzinger et al., 2017; Duran et al., 2017). Junior



cats may also experience play interaction with their owners more frequently than older cats, although associations between cat life stage and owner play time has not yet been investigated. Play sessions may increase the frequency of overall arousal the cat experiences, driving up HCC levels as demonstrated in dogs who routinely compete in flyball with their owners (Packer et al., 2020). Indeed, Ramos et al. (2013) report lower HCC in juvenile cats living in multi-cat households and hypothesise that inhibited play behaviour in households with several cats may be responsible.

Across other species, higher HCC levels have been found in younger animals compared to adults (Azevedo et al., 2019; Ferreira et al., 2005; González-de-la-Vara et al., 2011; Heimbürge et al., 2020). Comparison of age across species is difficult due to differences in development and maturity between ages, however. It must be noted that the animals in the aforementioned studies have typically been younger than the juveniles in this study, representing very young to recently weaned animals which may have very different physiological profiles, thus comparisons must be made carefully. It must also be noted that age and HCC has frequently been reported to have no correlation at all, in cats (Ziljstra, 2017) and across other species (Bechshøft et al., 2012; Macbeth et al., 2010). Differences in the significance of age may arise due to differential coding of age, with some studies treating age as a continuous variable, and other studies, including this one, classifying age based on life stages. The hypothesis that differences in HCC may be due to differential hair growth in younger animals (Azevedo et al., 2019) may, however, be applicable to juvenile domestic cats.

#### *ROOMS ACCESSED*

As the number of rooms a cat had access to increased, so did HCC levels. This is in accordance with Lichtsteiner and Turner (2008), who found that as the total living space within the home increased, so did basal cortisol levels. Larger homes likely have lower predictability than smaller homes, or greater arousal opportunities due to increased variation, in part due to the increased number of human or animal inhabitants that it may contain. Feline cortisol has been seen to be increased in households with a higher number of people (Lichtsteiner and Turner, 2008), owners with higher social scores (Ramos et al., 2012), or with exposure to dogs (McCobb et al., 2005). Carlstead et al. (1993) also found higher cortisol levels in cats with unpredictable or stressful caretaking routines, which might be seen in households

with more inhabitants if caretaking duties are split between family members and do not follow set routines. It must be noted that social composite score did not correlate with HCC within the model, however the social composite score may be more representative of the social diversity within the household than intensity, given that a score of '1' is given for the presence of children, cats, dogs or adults other than the owner, irrespective of whether this represents one individual, or five individuals. There may also be greater opportunities for positive arousal in larger households. As previously discussed, play activity may increase HCC in cats as it is seen to in dogs (Packer et al., 2020). Variation within the household may lead to more opportunities to explore, and a busier social environment may mean more opportunities for positive social interaction and arousal through play. Investigation into whether HCC correlates with the number of social opportunities available, both with humans, conspecifics and other species, is therefore warranted.

#### *AREA*

Living in villages or rural areas was found to produce higher HCC values than living in the city centre. Villages or rural areas might represent greater opportunity for arousal through hunting or stressful encounters with native wildlife when compared to city centres. Although it may be expected that city centre environments may be more stressful for cats due to noise, traffic, constantly changing scenery, unknown people and a higher density of conspecifics or dogs (Bradshaw, 2013), it may be that cats living in city centres are desensitised to their environment thus do not have higher HCC. Cats unable to cope with busy city centre environments may also be relinquished or opt to stay indoors, which may contribute towards explaining why cats with indoor lifestyles have higher HCC than cats who have access to the outdoors. It is also possible that houses in villages or rural areas are larger than, and have more rooms than, dwellings within the city centre. Overall, the effect of area type on HCC warrants further investigation, to ascertain which aspects of the outdoor environment may impact welfare in cats.

## 5. LIMITATIONS

Previous work has suggested coat colour may impact HCC across a range of species, such as dogs (Bennet & Hayson, 2010; Bowland et al., 2020), cattle (Burnett et al., 2014; Heimbürge et al., 2020) and pigs (Heimbürge et al., 2020), with studies typically reporting darker hair having lower HCC levels than light hair. In this study, however, it was not possible to control for coat colour. Given the self-selection

sampling method of this study, whereby owners were able to willingly opt-in and collect samples themselves, restricting coat colour would likely exclude large portions of participants thus reducing the overall sample size. It was also not possible to easily categorise coat colour for inclusion within the model due to the complexity of cat coat colours, with many cats exhibiting mixed coats e.g. tabby and white, tortoiseshell. Whilst it was considered that owners could be asked to specifically sample a certain colour of their cat's fur should they display it, e.g. black, this would change the sample site across individuals, introducing another variable. The decision was instead made to control for sampling site, as previous work on HCC has consistently suggested significant differences may be found between hair sampled from different regions in cats (Contreras et al., 2021) and other species (Acker et al., 2018; Burnett et al., 2014; Carlitz et al., 2015; Moya et al., 2014) and controlling for sample site would not reduce the number of owners who could participate if desired. Controlling for sample site was also beneficial from an ethical perspective, as the sample site chosen carried a lower risk of injury for both the cat and handler due to being away from the head of the cat. In studies with larger subgroups of each coat colour, it would be beneficial to control for colour so as not to introduce any additional variation.

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# DISCUSSION

Indoor-only lifestyles for owned domestic cats are increasing, and evidence from Chapter 3 (Foreman-Worsley et al., 2021), as well as other published sources (Tan et al., 2021), suggest they will continue to do so due to increasing urbanisation, fear of road traffic accidents and increasing rates of younger owners who are more likely to provide indoor-only lifestyles. Understanding how indoor-only lifestyles impact behaviour and welfare when compared to lifestyles that allow outdoor access is important. One can assess any positive or negative impacts upon the wellbeing of cats in these scenarios including whether cats may exhibit different behaviours that decrease or increase the risk of relinquishment or punishment. Available literature that considers the impact of lifestyle on behaviour or welfare in cats has typically done so through the inclusion of lifestyle as a minor variable within a large pool of variables (e.g. Amat et. al., 2009; Barcelos et al., 2018; Sandøe et. al., 2017). This has reduced the ability for researchers to understand the size of the effect lifestyle may have on behaviour and welfare and has meant that the mechanisms posited for any observed differences have been largely speculative. Thus, the research within this thesis is some of the first to explicitly focus on lifestyle as a major factor for consideration in behaviour and welfare of owned, domestic cats.

Throughout this thesis, the available literature on indoor-only cats has been explored in-detail through two systematic reviews, with several of the identified research gaps subsequently targeted. Given all cat owners must make a choice of lifestyle, the rationales behind these decisions have been explored, and subpopulations of owners and cats more likely to provide, or be provided with, specific lifestyles have been revealed. A range of owner and cat demographic variables, as well as environmental parameters, have been explored for their impact on problem behaviour scores across cats of different lifestyles. Finally, hair cortisol concentration (HCC), has been utilised to explore whether lifestyle, demographic or environmental features may impact physiological measures of stress in owned cats.

## IMPACT OF LIFESTYLE

### *DIFFERENCES BETWEEN LIFESTYLES*

This body of work has provided further evidence that cats with unrestricted outdoor access have lower problem behaviour scores than individuals kept as indoor-only, or those with managed indoor-outdoor lifestyles. It has also been shown that HCC levels significantly vary between cats of different lifestyles, with indoor-only cats having higher HCC levels than cats with managed or unrestricted indoor-outdoor lifestyles. Whilst it is not possible to make any inferences into welfare of these findings yet, it is useful to know that lifestyle and management appears to influence owner-reported behaviour and physiology of cats. It was considered that a reporting bias for problem behaviours may exist for owners who spend more time in proximity to their indoor-only cats than those who have access to outdoors. However, that HCC levels are also found to be higher in indoor-only cats indicates that lifestyle may have a substantial impact on a cat's lived experience as HCC levels cannot be affected by reporting bias. Given the rising evidence that lifestyle does impact behaviour, and potentially welfare, both from this thesis and external papers (Amat et al., 2009; Barcelos et al., 2018; de Souza Machado et al., 2020a; Finka et al., 2019; Heidenberger, 1997; Sandøe et al., 2017; Schubnel & Arpaillange, 2008; Tamimi et al., 2015), it is important to understand what factors about lifestyle result in these differences.

As evidenced throughout Chapter 3 and 4, differences in the physical and social environment, and cat and owner demographics, were found to be associated with lifestyle. These associations mean it is not possible to entirely attribute the variation in problem behaviour score or HCC to lifestyle alone. Whilst this does not mean that lifestyle itself does not have an impact on problem behaviour scores or HCC, it does demonstrate that it is important to consider the environment holistically. Indeed, the models produced in Chapter 4 and 5 demonstrate that many variables within the environment simultaneously impact problem behaviour scores and/or HCC. In Chapter 4, the model for problem behaviour scores were split across cats who were indoor-only, those who had managed indoor-outdoor access or those who had unrestricted indoor-outdoor access. These models revealed which components of the environment, or which demographic variables, were important influencers of problem behaviour scores for cats with differing lifestyles. It was revealed that in many instances variables do not appear to contribute



consistently with regards to their significance, their direction of effect, or the strength of their effect. This demonstrates that there are specific considerations owners of cats with different lifestyles need to factor into the care of their cat. In Chapter 5, due to sample size and unbalanced categories the HCC model could not be split across lifestyles as had been done in Chapter 4. However, lifestyle was included within the model as a variable and was found to be significant, indicating that HCC is impacted by lifestyle. It is reasonable to assume that should the sample size in Chapter 5 have been large enough to facilitate splitting the model into three models, one per lifestyle, similar results to Chapter 4 may have been seen, whereby variables such as area type, or daily hours spent alone without people may impact HCC levels differently based on the lifestyle of the cat.

#### *INDOOR-ONLY AND MANAGED INDOOR-OUTDOOR LIFESTYLES*

Differences between indoor-only lifestyles and managed indoor-outdoor lifestyles were not seen with regards to problem behaviour scores (Chapter 4). That there is no significant difference in the problem behaviour scores for indoor-only and managed indoor-outdoor cats may indicate that these lifestyles are not functionally different to one another from a cat's perspective. When considering catios, which may be a relatively small room (i.e. smaller than the size of a room within the home, perhaps reflecting the size of a shed or smaller) with mesh walls, or access to summer houses, these additional spaces may be functionally equivalent to an additional room within the home, rather than outdoor access. That is not to say they are not beneficial, such rooms may contain high levels of enrichment if they have been designed with the cat in mind, and we see within the models in Chapter 4 that access to additional rooms may reduce problem behaviour scores. In the wider literature, a recent study by de Assis and Mills (2021) showed the provision of contained garden access increased positive maintenance behaviours and decreased a selection of health and behavioural issues in a sample of 444 cats. Most of these cats did not have unrestricted outdoor access before system implementation, and for approximately a third of cats this represented a change from an indoor-only lifestyle to one with some form of outdoor access. Thus, additional space is likely to be beneficial. However, if this space is contained or restricted it may still not allow natural behaviours such as roaming, marking or hunting (Bradshaw, 2018) that may be beneficial for reducing problem behaviour scores. Indoor-only cats did have significantly higher HCC scores than those with

managed indoor-outdoor access. The difference in results may be due to problem behaviour score and HCC measuring different aspects relative to a cat's wellbeing, as seen by the lack of correlation between problem behaviour score and HCC. It may also be due to the differing proportions of the types of managed indoor-outdoor cats (e.g. leash, catio, supervised outdoor access) found in each study population. Further investigation into matched populations would be useful in determining the cause of these differences.

## OWNER ATTITUDES

### *OWNERS CONSIDER WELLBEING*

Chapter 3 provides strong evidence that most owners make decisions regarding lifestyle based on what they believe to be best for the wellbeing of their cat. Indoor-only owners typically feel the lifestyle is beneficial as it protects their cat from perceived dangers outdoors, such as road-traffic accidents or harm from other people or animals. Owners who provide outdoor access typically perceive the outdoor environment to be mentally and physically beneficial to their cats. The benefits of each type of lifestyle appear to be recognised universally by owners, regardless of the lifestyle they provided. This was evidenced through cat owners most often citing the major reason they would switch lifestyles as the major reason owners of the alternative lifestyle selected their form of management. However, most owners gave no active consideration to which lifestyle they would provide, suggesting a firm view of the perceived risks to, and responsible management practices of cats. These ideas of best practice are likely to be largely influenced by cultural perceptions, as evidenced in Chapter 3 where region was highly predictive of lifestyle, and as reflected in the wider literature (Grigg & Kogan, 2019; Harrod et al., 2016; Kendall & Ley, 2006; Roussel et al., 2019; Sandøe et al., 2017; Strickler & Shull, 2014; Tan et al., 2021).

### *OUTDOOR ACCESS VIEWED AS MENTALLY ENRICHING*

Evidence throughout Chapter 3 and 4 suggests that owners recognise the potential benefits of outdoor access with regards to enrichment and the opportunity to carry out natural behaviours, as has been suggested elsewhere to a lesser extent (Grigg & Kogan, 2019; McLeod et al., 2015). In Chapter 3, large portions of indoor-outdoor owners detailed the major reason they provide outdoor access is the potential benefit to their cat's mental health. Many owners also provided outdoor access as

they felt it was something that their cat desired, suggesting a belief that a cat having choice and control, or some form of autonomy, is good for their wellbeing. Themes identified from open-ended questions included viewing the outdoors as a good source of enrichment, with the opportunity for a wide range of daily activities than cannot be replicated within the home. The potential benefits to cat mental health were also the most common reason owners of indoor-only cats would switch to an outdoor lifestyle. In Chapter 4, we see further evidence that owners recognise the benefits of the outdoor environment, as owners of indoor-only cats were seen to provide their cat with high levels of enrichment and cat-specific items, likely recognising the indoor environment may be lacking in complexity compared to the outdoors and looking to mitigate any negative impact on wellbeing or behaviour this might have. In addition, through comparison of enrichment scores, it was identified that unrestricted indoor-outdoor cats were provided with significantly less enrichment than indoor-only cats, a finding recently echoed by Tan et al. (2021). Concerningly, this might suggest that owners of cats with outdoor access feel the outdoor environment is enrichment enough to meet the behavioural needs of their cats, and thus do not endeavour to provide items within the home. Whilst it may be good that the potential benefits of outdoor access are realised, it is essential for owners to recognise that ensuring a cat-friendly indoor environment is also important, as cats with outdoor access may still spend large portions of their time indoors.

## CONTRADICTIONARY RESULTS BETWEEN STUDIES

A more general finding throughout this thesis was an inconsistency of results within the currently available literature. Systematic reviews in Chapters 1 and 2 (Foreman-Worsley and Farnworth, 2019; Finka and Foreman-Worsley, 2021) demonstrate the complexity of analysing data that contains many environmental variables. This complexity has often led to contradictory results between studies, making meaningful interpretation and practical application of the current body of evidence difficult.

The systematic review of indoor-only cat literature (Foreman-Worsley and Farnworth, 2019: Chapter 1) revealed several literature gaps, including those for cats within the domestic home, and problems with small sample sizes or relatively repetitive studies where a consensus seemed to be agreed between results e.g. the benefits of the ability for cats to hide on stress. Chapter 1 also revealed a lack of

research regarding cats and the social environment, and that the scarce literature available on multi-cat households did not hold consensus on the overall impact this might have on wellbeing. A review into multi-cat households was therefore undertaken to ascertain whether a more targeted review might provide clarity on the direction of effects multi-cat households might have on wellbeing, and to identify reasons that might contribute towards inconsistency within the literature. However, the second review further highlighted the difficulties faced by researchers in the field and demonstrated further confounding conclusions and the high number of variables that may impact on the overall wellbeing of cats.

Given the contradictory information found across Chapters 1 and 2, a literature review was conducted within Chapter 4 exploring links between environmental and demographic variables and problem behaviour, with similar issues noted (e.g. Barcelos et al., 2018; Finka et al., 2019; Heidenberger, 1997; Kogan & Grigg, 2021; Wassink-van der Schot et al., 2016; Yamada et al., 2020). These results were used in the creation of a composite problem behaviour score. Composite scores were also created for environmental enrichment, and social environment. Composite scores can be used to reduce the number of analyses and confusion resulting from multiple variables. They may also improve practical interpretation of the outcomes and identify whether general dimensions of a cat's environment might correlate with problem behaviour scores, although further research is likely to be needed to elucidate any mechanisms that result in correlations being observed. Evidence suggested both the environment and social scores have an impact on the problem behaviour score as detailed in Chapter 4, and differences were found between lifestyles, suggesting these composites were useful.

## FUTURE RESEARCH

Further evidence to elucidate whether hair cortisol concentration may correlate with problem behaviour score at more extreme ends of the scale would be useful. As discussed, problem behaviour scores within this study were typically low to moderate, and in some cases completely absent. This is likely due to the recruitment method, which due to being self-selecting, may encourage responses from enthusiastic cat owners. These owners may be more attentive to the care and welfare of their animal, or more likely to seek veterinary assistance for behaviour problems. Further data collection with samples that contain problem behaviour

scores throughout the entire range of the composite scale would help to provide evidence whether no correlation is present, or if problem behaviours within this study were too low on the spectrum to correlate with HCC. Recruitment of these participants could be done through veterinary clinics where owners are seeking help for problem behaviours, with hair sampling being completed at the same time.

Detailed exploration of the outdoor environment and the components that may influence behaviour and welfare in cats with outdoor access is warranted. Within this thesis, results have indicated that area type (e.g. urban, rural) plays a role in influencing both problem behaviour score and HCC. A scarcity of research on the outdoor environment means it is not yet understood why this is, although suggestions have been given throughout this thesis. Aspects of the outdoor environment that may warrant investigating are the complexity of the outdoor environment (e.g. a barren yard, compared to a plant-filled garden, compared to a busy urban environment), the level of social intensity from neighbouring people, cats and dogs, and any inter-cat conflict with neighbouring conspecifics (Little, 2016), the available opportunity to exhibit natural behaviours such as roaming, marking or hunting, and the predictability of the levels of activity or noise (Bradshaw, 2013). The impact of outdoor provisions or enrichment (e.g. litter trays, water sources, hiding holes or toys) could also be considered, as they may be beneficial outdoors as they have been suggested to be indoors (Lawson et al., 2019; Mengoli et al., 2013). Any research into the outdoor environment should consider and control for aspects of the indoor environment which may correlate with different area types, such as house size, the number of rooms a cat has access to, the number of people or animals the house might be able to host, or the type of outdoor access a cat may have (Foreman-Worsley et al., 2021; Lichtsteiner and Turner, 2008; Ramos et al., 2012; Tan et al., 2021; Tomlinson, 2016).

Temporal stability of owner opinions with regards to their choice of lifestyle would be a useful avenue for further research. Chapter 3 revealed factors that may be predictive of lifestyle, many of which could be associated, for example, owners with cats of indoor-only lifestyles were more likely to live in apartments, in city centres or urban environments, and fall into younger age categories, when compared to middle-aged owners living in suburban areas. It is not yet known whether differing attitudes towards lifestyle and its association with owner age are reflective of

generational differences that will remain constant throughout the entirety of the owner's life, or whether chosen lifestyle might change from indoor-only when younger, to providing indoor-outdoor lifestyles as owners age and move out of city centres and urban areas. Understanding whether perceptions are fixed or changeable could give indication as to how overall proportions of each lifestyle might change e.g. increasing numbers of indoor-only cats for a while, as younger people become first time cat owners, which will then peak and then remain constant as these owners move home and allow outdoor access, or whether the number of indoor-only cats will continue to rise with each subsequent generation. Understanding future levels of indoor-only cats and how rapidly we may see any increase will give indication as to the timeline cat welfare professionals should be working to when considering additional research or owner education to ensure low levels of problem behaviours, and strong cat-owner bonds.

## RECOMMENDATIONS

**INCREASING ADVICE:** Veterinarians, charities and animal welfare professionals should provide information on the importance of environmental provisions for all cats, inclusive of those with outdoor access. It is often recommended that owners of indoor-only cats provide additional enrichment to ensure a stimulating environment (Cats Protection, 2015; Herron & Buffington, 2010; Scherk, 2021), and results throughout Chapter 3 and 4 suggest that many owners may be aware of, and actively following, this advice. However, a disparity in environmental provisions were seen between indoor-only and both types of indoor-outdoor cats. Given most cats with outdoor access will still spend a large portion of their time indoors, especially if not provided with outdoor access in an unrestricted capacity, the indoor environment likely contributes substantially to their behaviour and welfare. Having enrichment and essential items such as litter trays or scratching posts within the home will likely be beneficial (de Souza Machado et al., 2020b; Lawson et al., 2019; Mengoli et al., 2013; Strickler & Shull, 2014), provided owners do not use enrichment as an alternative to social interaction, play or other forms of care (Amat et al., 2009; Heidenberger, 1997; Schubnel & Arpaillange, 2008; Tamimi et al., 2015; Yamada et al., 2020).

**LIFESTYLE CATEGORISATION:** Studies regarding lifestyle, management, welfare and problem behaviours in indoor-only cats when compared to those with outdoor

access are increasing. However, few studies to date have aimed to investigate whether differences are found between cats with managed indoor-outdoor lifestyles (i.e. those with some level of restriction placed upon them, such as time-restricted outdoor access, leash walking, owner supervision, garden containment or catios) in contrast to unrestricted indoor-outdoor cats, who are able to access the outdoors at any time, and roam freely once outside. Where investigation separating managed and unrestricted indoor-outdoor lifestyles have been conducted categorisation of indoor-outdoor lifestyle types has been variable (Barcelos et al., 2018; Elzerman et al., 2019; Finka et al., 2019; Sandøe et al., 2017). This study found strong evidence that significant differences exist between the three lifestyle categories, notably including differences between managed indoor-outdoor cats, and both indoor-only and unrestricted indoor-outdoor cats, with regards to both levels of owner-reported problem behaviours and environmental variables. These results suggest that within future research, cats with managed indoor-outdoor access should be acknowledged as a separate lifestyle category to cats with unrestricted indoor-outdoor access, as opposed to being included within one over-arching indoor-outdoor category.

**PROVIDE OUTDOOR ACCESS:** Where possible, it may be beneficial for indoor-only cat owners to provide some form of outdoor access. In this thesis, an increase in problem behaviour scores were found as cats were restricted in their outdoor access, and higher HCC levels were found in indoor-only cats compared to managed or unrestricted indoor-outdoor cats. It has also been demonstrated elsewhere that access to additional space may lead to lower problem behaviour scores in indoor-only cats (de Assis and Mills, 2021). Many owners appear to recognise the potential benefits of outdoor access on a cat's mental and physical wellbeing; however they are often swayed to an indoor-only lifestyle based on safety concerns. Therefore, for cats currently exclusively confined to the indoors, even confined outdoor access may be beneficial to both cats and their owners. Caution should be taken when restricting a cat with previously unrestricted outdoor access to a confined lifestyle, however, as this may represent a relative loss of freedom for the cat that could be detrimental to wellbeing.

**SOCIAL INTERACTION IMPORTANCE:** Upon purchase or adoption, the potential importance of social interaction between cats and owners should be explained. This

thesis, and wider results (Amat et al., 2009; Heidenberger, 1997; Schubnel & Arpaillange, 2008; Tamimi et al., 2015; Yamada et al., 2020), provide evidence that social interaction may help to mitigate problem behaviours in owned cats. Interaction may take the form of playing and simulating hunting behaviour, or of grooming and petting, always ensuring that the cat has choice and control within the situation and is free to leave if they so desire (Haywood et al., 2021). Guidance that cats should not be left alone for long periods should also be provided, as chapter 4 and recent studies into separation-related problems in cats have suggested cats may suffer anxiety that manifests in problem behaviours when their owners are not around (de Souza Machado et al., 2020b).

COMPOSITE SCORES IN RESEARCH: For future research in this area and others, it would be pertinent to bear in mind how certain methodologies may lead to results that do not have meaningful applications, or the likelihood of type 1 errors arising due to multiple testing of variables. Looking at the major aspects of a cat's environment may have more practical outcomes for cats whilst the levels of literature remain low, and this could be achieved through composite scores. To ensure meaningful grouping of variables into composites, the biological relevance of composite scores and their components should be considered, and items within a composite should be strongly related. This can then allow exploration of overarching components of a cat's environment (e.g. relationships with people, relationships with people, outdoor environment), whilst reducing the overall number of variables within analysis. Measures of internal consistency within variables grouped into composite scores may help ensure the robustness and validity of the composite.

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# APPENDIX

## A1. CHAPTER 1: INDOOR-HOUSING REVIEW PAPER SUMMARIES

<b>Social interaction with cats</b>		
<b>Reference</b>	<b>Study topic</b>	<b>Significant findings</b>
Barry and Crowell-Davis, 1999	Impact of gender on social behaviour of pairs	No impact of gender. M/M spent more time near each other than other gender pairing, although affiliative behaviour was the same. Aggression was negatively correlated with time spent living together.
Bernstein and Strack, 2015	Spatial occupation within a home	Individual ranges varied in size yet overlapped and were timeshared. Adult males had larger ranges than female. Kittens had large range which decreased with age. No evidence for hierarchy besides 1/2 dominant cats.
Bradshaw and Hall, 1999	Behaviour between (un)related cats	Littermates had more friendly interactions with each other in all categories (physical contact, grooming, close feeding) than unrelated pairs.
van den Bos and de Cock Buning, 1994	Group dominance	Cats with higher rank: performed more social licking, emit more offensive threats, received more social sniffing and rubbing, spent more time on the floor and less time hiding and gained weight. Dominant cats occupy larger areas.
van den Bos, 1998 (a)	Post-conflict behaviour	Grooming, head shaking, scratching and oral behaviour are significantly increased immediately following conflict, most notably in the first minute. Possible markers of acute stress response or self-soothing.
van den Bos, 1998 (b)	Function of allogrooming	MM or MF grooming more common than FF. Relatedness did not impact behavioural patterns. Higher ranking animals groomed lower ranking animals more often than vice versa. Groomers often autogroomed after allogrooming.
Damasceno and Genaro, 2014	Impact of feeding enrichment on behaviour	Enrichment best provided in am when cats most active. Increasing item number increases interaction. Dominant members may take control so enrichment not beneficial to all members. Spatial arrangement of items is important.

Dantas-Divers <i>et al.</i> , 2011	Impact of feeding enrichment on group behaviour	Most agnostic interactions not due to physical resources. No correlation between time spent with puzzle feeder and aggression.
Desforges, Moesta and Farnworth, 2016	Impact of enrichment (vertical space) on behaviour	Significantly more cats off ground when shelves present. Cats significantly more likely to occupy shelves and bedding than corridors or litter trays. Pre-feed agonistic behaviours more likely than post-feed. Less agonistic behaviours post-feed in am with screen. Significantly more agnostic behaviours pre-feed PM during removal phase. More affiliative behaviours post-feed when screen not present.
Ellis, McGowan, and Martin, 2017	Litter box sharing	Cats preferred to urinate/defecate in a clean litter box. If dirty, no preference over own/others.
Ellis and Wells, 2010	Impact of olfactory enrichment on behaviour in single, pair and group shelter housing	Olfactory stimulus significantly influenced behaviour of shelter cats (namely standing, resting, sleeping, moving, grooming, socialising and location). Cats exposed to catnip spent significantly more time interacting with cloth than others. Significantly more time spent with cloth in first half hour than second or third demonstrating strong novelty effect.
Ellis and Wells, 2008	Impact of visual enrichment on behaviour in single, pair and group shelter housing	Cats spent significantly longer looking at animate and inanimate movement than blank screen. Significantly more time spent looking at screen in first hour than second and third showing that novelty is important.
Fazio <i>et al.</i> , 2017	Stress in cattery vs household	Significantly higher total cortisol concentrations in household cats. Physiological differences between male and female cats.
Gouveia, Magalhães and de Sousa, 2011	Impact of LOS and gender on behaviour in group shelters	Cats with greater LOS significantly less active, more negative encounters and spent more time eating. Higher cat density meant more frequent negative encounters. Male:female ratios significantly impacted grooming and inactivity.
Kessler and Turner, 1997	Stress in single vs pair vs group cattery housing	CSS greatly declined after two weeks, most significant decline in the first four days. Housing style did not affect CSS. CSS declined significantly in singly cats between day 1 and 5. In pairs and groups CSS declined significantly between day 1 and 4.
Kessler and Turner, 1999 (b)	Impact of cage size in single vs group housing	Cats in larger cages had a significantly lower CSS than smaller cages in first week. CSS of 'weakly tense' avoided below a minimum density of 0.62m <sup>2</sup> . Acclimatisation seemed to occur after 2 weeks.

Lichtsteiner and Turner, 2008	Stress and dominance in a group home	Intra-individual variance in cortisol levels were low. In the home, human density, number of persons, m <sup>2</sup> per cat impacted cortisol. Cortisol levels of house cats and shelter cats did not differ significantly.
Loberg and Lundmark, 2016	Impact of density on stress in group housing	Solitary play and movement between resources significantly increased with increasing space. More positive social interaction in larger spaces. More activity in the afternoon. CSS did not vary between areas of different sizes.
McGlone <i>et al.</i> , 2018	Impact of pheromones on tray use and aggression	Cats with pheromone had significantly less aggression in the first six hours but effect diminished afterwards. Control group spent more time using the litter box and had more aggressive encounters.
de Oliveira, Terçariol and Genaro, 2015	Impact of enrichment (boxes) on behaviour	Significant differences in the use of space with and without interaction with the enrichment object when compared to the use of space without enrichment. Use of refuges can increase the amount of space that felines use, both when interacting and not interacting with the object. Ground level preferred for interaction, mid-height preferred for LOS.
Ottway and Hawkins, 2003	Stress in single vs group shelter housing	Overall CSS and hiding time significantly higher in communal housing. Playing or sleeping in contact with conspecific significantly more frequent in discrete. Agnostic encounters significantly more frequent in communal housing. Stable groups or single housing produced least stress.
Ramos <i>et al.</i> , 2013	Stress in single, pair and group houses	Cats that "tolerated" being brushed/stroked had sig higher GCM than those who disliked/liked it. GCM showed greater inter-individual variability than other studies.
Rochlitz, Podberscek and Broom, 1998	Welfare during quarantine	Changes to body condition in 66% of cats. During quarantine owners reported cats were more detached, less relaxed, more excitable, more aggressive, less playful and more nervous during quarantine, suggesting stress. After, owners reported cats spent more time with owners than before.
Uetake <i>et al.</i> , 2013	Stress in single vs group shelter housing	Cats significantly more active in group-housing than caged. Cats played significantly more (alone and with one another) in group housing. Cats tended to rest more in cages and were less active. No significant differences in C:C between groups.

<b>Social interaction with humans</b>		
Reference	Study topic	Significant findings

Arhant and Troxler, 2017	Impact of caretaker attitudes on cat behaviour	Cat behaviour did not reflect caretaker attitudes. Increased contact significantly correlated with more frequent provision of fresh water, more frequently cleaned food bowls, more space per cat, opportunity to hide. Significantly fewer cats allowed contact with higher LOS in shelter and shelters with more 'difficult to rehome' cats.
Carlstead, Brown and Strawn, 1993	Effect of unpredictable routine on stress	Unpredictable routine lead to significantly elevated cortisol, enhanced ACTH sensitivity and reduced LHRH sensitivity, suppressed play and exploration, and increased awake time and hiding attempts. Cortisol negatively correlated with time spent hiding.
Ellis <i>et al.</i> , 2015	Effect of human stroking on behaviour	Handling by owner elicited a significantly greater number of negative behavioural responses than a stranger. Handling at the base of the tail had significantly more negative response than elsewhere.
Eriksson, Keeling and Rehn, 2017	Effect of separation on cat behaviour and owner interaction	No behavioural differences during separation between treatments. Upon owner return, cats purred and stretched significantly more after four hours and owners had significantly more verbal contact.
Kogan, Kulus and Schoenfeld-Tacher, 2017	Clicker training	Significant differences in all behaviours post-training.
Kry and Casey, 2007	Effect of hiding enrichment on stress	CSS significantly decreased between day 1 -5 in enriched pens, and further on day 14. In control, CSS increased between day 5 and 14. Cats w/ enrichment significantly more likely to approach and display relaxed behaviours. More active rest in control cats. Those with hiding enrichment spent significantly more time in it than in control bed.
Mertens, 1991	Interaction between cats and owners	Humans approached cats more frequently than vice versa. Cats approached, withdrew, and spent more time with adults than children, and females than males. Indoor cats had a higher activity and a smaller frequency of head/flank rubbing.
Moore and Bain, 2013	Effect of enrichment on stress	Between day 1 - 3 and day 1 - 5 there was a significant decrease in CSS and increase in HAT score in all cats. Enrichment did not impact CSS.
Rehnberg <i>et al.</i> , 2014	Enrichment preferences and effect on stress	Cat igloo and upper cat tree significantly preferred. Positive relationship between CSS and cat igloo usage. High CSS significantly correlated with reduced activity, eating, grooming and elimination. Cats with extended social interaction had significantly lower CSS and lower faecal cortisol trend.



Rochlitz, Podberscek and Broom, 1998	Stress during quarantine	C:C ratio significantly decreased on day 32/60/120 vs day 1. LOS correlated with significantly more sleeping, less hiding, more grooming. Being high preferred to floor. C:C ratios seem to support behavioural observations regarding stress.
Soennichsen and Chamove, 2002	Effect of human familiarity and stroking on behaviour	A significant location effect correlated with negative behaviours. Significant preference for stroking in temporal region by owner. Caudal stimulation received the highest negative behaviours. Purring present during aversive behaviours.
Stella, Croney and Buffington, 2014	Effect of enrichment and managed environment on behaviour	Food, toileting and sickness behaviour when initially confined. Managed environments had significant decrease in sickness and hiding behaviours between day 1/2, and a significant increase in maintenance and affiliative behaviours at the end of day 1. Managed cats with enrichment significant difference in hiding between day 1/2. Managed, unenriched cats significantly more affiliative behaviours.
Stella, Croney and Buffington, 2017	Effect of enrichment on stress in larger cages	Same patterns of behaviour and response to previous study (above). Suggests floor size not as important as other aspects of enrichment in terms of welfare.
Wedl <i>et al.</i> , 2011	Interaction between cats and owners	Females and cats have more interactions and more intense relationships. Cat gender did not matter. Older cats interacted less. Human personality has a significant impact on the relationship, as did cat personality.
Vitale Shreve, Mehrkan and Udell, 2017	Enrichment preference test	Social interaction significantly preferred over toys and scent, but not food. Playing with human was significantly preferred over playing with toy. Food was preferred significantly over scent. No differences between shelter cats and owned cats.

<b>Effect of physical environment</b>		
<b>Reference</b>	<b>Study topic</b>	<b>Significant findings</b>
Chadwin, Bain and Kass, 2017	Impact of pheromones on stress in shelters	No sig diff between URTI or CSS with pheromone. Significant URTI in strays held 2 per cage. CSS significantly affected by time in holding, stray/relinquished status, or environment.

Ellis <i>et al.</i> , 2017	Enrichment preferences of shelter and stray cats	Hiding significantly preferred to other sections. Surrendered cats spent significantly more time in control than strays.
Grigg, Pick and Nibblett, 2013	Litter box preferences	No significant preference for either un/covered tray type although some individuals displayed a marked preference.
Kennedy <i>et al.</i> , 2018	Enrichment preferences (toys)	No differences between FIV+ and FIV- cats. Significant preferences for: inclined scratchers vs flat; laser vs ball; humans vs ball.
McCobb <i>et al.</i> , 2005	Welfare in enriched vs unenriched	No significant correlation between cortisol:creatinine and CSS. No enrichment had sig higher C:C ratios than enriched. Significantly increased c:c measured with dog exposure (yet not CSS). C:C correlated with systematic disease.
De Monte and le Pape, 1997	Enrichment preferences (toys)	Cats significantly more active with enrichment. Duration of ball-play longer than log. Novelty observed day one for both enrichment types. Activity maintained more with ball rather than log.
Naik <i>et al.</i> , 2018	Impact of enrichment (feeding puzzle) on behaviour	Feeding enrichment does not appear to increase daily activity. Age does have an impact on daily activity with a decrease in activity as cats age.
Snowdon, Teie and Savage, 2015	Cat music as enrichment	Preference for 'cat music' with significantly more orient and approach behaviours and lower latency. Age impacted latency to response. Human music did not cause avoidant behaviour.
Strickler and Shull, 2014	Environment and behaviour of cats at home	63% of cats indoors-only. Significantly fewer behaviour problems when owners played for 5 mins+ vs 1 min. Females significantly less likely to have 1+ behaviour problems. Owners of cats with more undesirable behaviours significantly more likely spend more time outside. Owners of hunting cats significantly more likely to report more behaviour problems.
Vinke, Godijn and van der Leij, 2014	Impact of enrichment on stress in shelter	Mean CSS decreased faster over 14 days in enriched group. Enriched housing CSS stabilising on day 3, control on day 5. CSS on day 3 and 4 significantly higher in control.
Zhang, Plummer and McGlone, 2018	Scratcher enrichment preference	S-shaped cardboard scratcher significantly preferred over others. Study agrees catnip does not appear to affect cats <3 months.

**Social interaction with multiple species (humans, dogs and/or cats)**

Reference	Study topic	Significant findings
Adamelli et al., 2005	Effect of social and physical home environment on welfare	Owners pay more attention to care and physical needs than behavioural needs. Owner conditions e.g. number of people in the house, age of owners, people who took responsibility for cat had more influence over conditions rather than cat characteristics e.g. age, gender etc. and the cat features that were most important were influenced by the owner e.g. neutering, age of adoption.
Broadley, McCobb and Slater, 2014	Effect of previous homing on stress in shelter	Longer LOS significantly correlated with lower CSS. CSS has a change of inflection at four days. CSS significantly decreased with increasing age.
Feuerstein and Terkel, 2008	Interaction of cats and dogs in the home	Cats directed more play behaviour, aggression and submission towards dog. Female cats significantly more aggression and indifference, plus lower amicability to dogs. Neutered female cats significantly more submissive and frightened behaviour towards dogs. Cats adopted first meant sig more amicability from dog than indifference. Animals introduced younger significantly more mutually amicable. Behaviours well interpreted by other species.
Gourkow and Fraser, 2006	Effect of handling and housing on stress and adoption	Cats housed in basic, single cages had the highest CSS compared to cats in basic group housing or enriched single and group housing.
Heidenberger, 1997	Environment and behaviour of cats in the home	Significantly more behavioural problems reported with: limited/irregular outdoor access, groups of 2 or 3, less space per cat.
Kessler and Turner, 1999 (a)	Effect of socialisation on stress in single and group housing	Cats not socialised to people significantly higher CSS. Cats not socialised to cats significantly higher CSS in group housing. High CSS settles after few weeks.
Parker <i>et al.</i> , 2017	Spatial occupation in a group home with humans	Individual variability in activity levels, conspecific interaction and favoured conspecific. High places favoured for resting. Activity peaks at 6am, 8am/9am (when people entered), 2pm/3pm, 9pm.
Podberscek and Blackshaw, 1991	Effect of human presence on behaviour in group housing	Cats most active between 8am-9am. Cats made significantly more contact behaviours with unfamiliar people. Cats spent time off the floor or in a box.
Ramos, Arena and Reche Jr, 2012	Stress in single and group houses	Significant increase in cortisol with higher owner social QOL. No significant differences found between single/group housed cats.

Shyan-Norwalt, 2005	Behaviour of cats in the home	Cats spend < 5 hours a day looking out of the window. Cats thought to be looking at animate objects (e.g. bird or plants).
Thomson and Mills, 2018	Environment and behaviour of cats in the home	Cats with greater time indoors had greater amicability with dogs. Owners perceived 'cat factors' to be more important than 'dog factors' when considering amicability. Amicability influenced by age of cat introduction to dog (younger age, greater perceived amicability).

## A2. CHAPTER 2: MULTI-CAT HOUSEHOLD PAPER SUMMARIES

Author, date and title	Study design	Stated aim of paper	Subjects/ population demographics	Social and environmental parameters measured	Relevant features of cat living environment reported:	Measured parameters relevant to aspects of wellbeing	Data collection period and frequency of welfare measures collected	Intervention/comparison
Olm & Houpt (1988). Feline house-soiling problems <sup>52</sup>	Observational descriptive, retrospective	To determine the types of feline behavior problems encountered by owners and describe the types of house-soiling problems. The responses (i.e. owner specified outcomes) to the suggested treatments	<b>Subjects:</b> 59 owners and cats in the USA presenting with elimination problems at the Animal Behavior Clinic in university veterinary medicine department. <b>Owner demographics:</b> None other provided. <b>Cat demographics</b>	<b>Social environment:</b> Veterinary interview collected information on the following, although these were not reported in the paper - environment, early history, social behaviours including sexual and maternal, grooming and	<b>Social environment:</b> 19 single cat households. 24 households of 2. 16 households of 3+. <b>Physical environment:</b> None provided.	A behavioural consultation with the cat owner was used to extract information regarding the presence of problem behaviours (e.g. housesoiling, aggression, hypersexuality, excessive vocalisation)	Initial veterinary consultation, often inclusive of a single house visit to inspect the environment. Follow-up after treatment - time post-initial consultation unspecified.	Descriptive reporting of behavioural problems, with focus on house-soiling, and changes to behaviour after veterinary treatment and recommendations. No statistical analysis carried out.

		also evaluated	: 29 males (25 neutered, 4 unneutered) and 30 females (26 neutered, 4 unneutered).	feeding behaviour. <b>Physical environment:</b> None mentioned.		veterinary history.		
Heidenberger (1997). Housing conditions and behavioural problems of indoor cats as assessed by their owners <sup>2</sup>	Cross sectional survey with both descriptive and analytic elements	To explore the living conditions of cats kept predominantly indoors and identify problems associated with housing and behaviour, as reported by the cat's owner	<b>Subjects:</b> 550 owners of 1177 cats in Germany recruited via announcement in animal magazine. <b>Owner demographics</b> : 87% female respondents. Average ownership of 4 cats over 10 year period. <b>Cat demographics</b> : 766 non-pedigree (i.e.	<b>Social environment:</b> Some basic proportional data presented regarding duration of human handling received each day and time left alone, in addition to litter tray and food provisions. Density of cats and humans per household. <b>Physical environment:</b> Available space	<b>Social environment:</b> Average 2.3 persons per household and 2.2 cats. Cats handled by owners average 2.5 hrs per day and left alone for 6 hrs. 41% of the 550 households were single cat households (the rest presumably multi-cat), and 15% owned cats and dogs. <b>Physical environment:</b> 14% of households allowed their cats unrestricted access to outdoors, 29% were allowed access under supervision. 41% households located in city, 38% suburbs and	Owner reported presence of behavioral problems (yes/no) including anxiety, scratching furniture, undesirable feeding behaviour, aggression, undesirable urination, spraying and defecation, sexual behaviour,	Information extracted from a single sampling event (survey). Some questions about cat's daily routine and normal behaviour included, although associated time periods unspecified.	Chi <sup>2</sup> conducted on the relationship between the occurrence (yes/no) of cat behaviour problems and anxiety, and cat, owner and housing related factors. Various other information

			domestic short hair) and 411 pedigree (including range of 20 breeds) cats. 571 males, 594 females, 12 unknown. 76% neutered. Average of 5 years (SD 3.8) although authors state most cats 'only a few years old'.	to cat, type of access to the outdoors and the presence of other pets also presented. Opportunities for climbing and play surveyed.	21% country. Average indoor space available to each cat 34m <sup>2</sup> over 2 rooms. 1.9 litter trays per household, with 51% cats having to share a litter tray and 28% cats having 2 or more trays in different locations. Litter trays cleaned more than once a day in 61% households. In 79% litter trays placed in kitchen or bathroom. All cats reported to be fed regularly in same room, with 24% not having their own food bowl. <b>Other:</b> 46% cats went to vets once a year, 28% more than once a year.	liveliness, escaping, roaming and hunting. Owner descriptions of cat's character (e.g. attention seeking, shy, anxious, terrified, attached).		presented descriptively.
Pryor et al (2001). Causes of urine marking in cats and	Cross sectional survey with both descriptive and	To evaluate the effects of environmental management on urine marking	<b>Subjects:</b> 74 owners and cats in the US recruited via local vets and announcements	<b>Social environment:</b> Cat noted as coming from single or multi-cat household.	None provided.	Daily frequency of urine marking recorded by owner.	Daily records of number and location of urine marks within the house,	Z-test of proportion used to determine whether male cats

effects of environmental management on frequency of marking <sup>25</sup>	analytic elements. Impact of interventions for marking assessed via observational, case study without controls.	frequency and obtain demographic data on marking cats and owner's perception of contributing factors	ts in regional newspapers. <b>Owner demographics</b> : None other provided. <b>Cat inclusion criteria:</b> Only one marking cat per household, 4 or more urine marks on indoor vertical surfaces each week, four or less cats in the household, neutered, healthy cats not receiving medication for marking behaviour. 23 cats later excluded from original	<b>Other:</b> Owner interviews conducted and their perceptions of causative factors for urine marking noted.			during a two week baseline period, followed by 2 week environmental management phase.	and those from multi-cat households were over represented in sample population, compared to average population of cats in Californian households. Paired t-tests conducted to compare frequency of urine marking between baseline and environmental management
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			cohort. <b>Cat demographics</b> : None further provided.					t phase. For management phase, owners were given verbal and written instructions regarding litter tray cleaning and provision, and urine mark cleaning.
Adamelli et al (2005). Owner and cat features influence the quality of life of the cat <sup>40</sup>	Cross sectional survey with both descriptive and analytic elements	To investigate how features of owners and cats can influence cat quality of life	<b>Subjects:</b> 62 owners and cats in Italy recruited among university staff and their acquaintances. <b>Owner demographics</b> : 85.5%	<b>Social environment:</b> Owner features - age, gender, education, family members, house size, pet ownership experience, primary	<b>Social environment:</b> 51.7% lived with other cats, 25.8% with dogs, 12.9% with other species. <b>Physical environment:</b> 61.2% owners lived in a town, 42% in a house.	Physical exam to determine nutritional status of cat and ear condition (unspecified if performed by owner or vet). Owner	Information extracted from a single sampling event (survey). No time frame specified for provision of information relevant to	ANOVA, Kruskal-Wallis used to assess relationships of welfare measures (physical exam, cat care q's, cat behaviour

			<p>women. Age range of 18 to 76. <b>Cat demographics</b> : Cats between 11 months and 10 years. 66.2% female (78% neutered), 33.8% male (66.6% neutered). 92% mixed breed. 58% previously had a disease.</p>	<p>caretaker, friendship group and emotional bonds, social activities. Lexington attachment to pets scale (LAPS). <b>Physical environment:</b> None mentioned.</p>		<p>reported basic cat care provisions reported by owner (e.g. veterinary care, diet, grooming), cat behaviour (e.g. owner interactions, elimination, social behaviour towards owner, strangers, cohabiting animals, unknown cats). Outcomes of these variables were ranked,</p>	<p>outcome measures.</p>	<p>q's, QoL, LAPS) to owner and cat features.</p>
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						<p>scores totalled for each aspect (i.e. exam, care, behaviour) and then combined to create overall quality of life score.</p>		
<p>Levine et al (2005). Inter-cat aggression in households following the introduction of a new cat<sup>18</sup></p>	<p>Cross sectional survey with analytic elements</p>	<p>To identify potential risk factors associated with inter-cat aggression within a household post adoption of new cat, to quantify incidence of inter-cat aggression and obtain</p>	<p><b>Subjects:</b> 252 owners of 252 cats in the USA adopted from a shelter were contacted. <b>Owner demographics</b> : None other provided. <b>Cat demographics</b> : 128 multicat and 124 single cat households.</p>	<p><b>Social environment:</b> For multi-cat households - behaviour of cat prior to newly adopted cat and afterwards, relationships between original cats in households, age, sex, neuter status of original cats.</p>	<p><b>Social environment:</b> In multi-cat households 65.4% of homes had one other cat, 21.3% had two other cats and 3.4% had 3 or more other cats. <b>Physical environment:</b> 46.4% cats had outdoor access. Adopted cats had been home for between 2 months and 1 year at time of study.</p>	<p>Owner reported incidents of cat fighting and aggression including type (biting/scratching) and owner perception of cat interactions</p>	<p>Information extracted from a single sampling event (survey). Owner observations based on period of time since new cat adoption (ranging between 2</p>	<p>Chi<sup>2</sup> tests used to find significant associations between variables. When identified, all possible pairs examined, and Bonferroni corrections applied to</p>

		descriptive information on methods used to introduce new cat	For multicat households: Introduced cats - 59.4% female. 39.7% <3 months, 17.5% 3-6 months, 30.2% 6 months to 2 years and 12.7% >2 years. Single cat households: 64.2% female. 29.8% <3 months, 21% 3-6 months, 33.9% 6 months to 2 years and 15.3% >2 years.	Method of introduction. Size of home. <b>Physical environment:</b> Outdoor access.		at first meeting.	months and 1 year from survey completion). Owner observations provided for two time points - at initial cat-cat introduction and "current" behaviour. Reported cat-cat fighting recorded as frequency per week.	the p-value. Univariate analysis followed by multivariate logistic regression to assess fighting (yes/no) and multiple risk factors (e.g. sex) simultaneously.
Kendall & Ley (2006). Cat ownership	Cross sectional survey with both	To test various hypotheses relating to	<b>Subjects:</b> 181 owners of 343 cats in Australia	<b>Social environment:</b> Incidents of aggressive	<b>Social environment:</b> 30% households contained children, over half of households contained	Owner rating of cat's 'temperament' i.e. level	Information extracted from a single sampling	Chi <sup>2</sup> tests used to determine relationship

<p>in Australia: Barriers to ownership and behavior<sup>44</sup></p>	<p>descriptive and analytic elements</p>	<p>reduced ownership due to supply shortages caused by increased population control measures, whether cat coat colour relates to their temperament, and whether owner observations could provide insight into the behaviours of cats living with humans</p>	<p>recruited via local vets and online. <b>Owner demographics</b> : 96% female respondents, most between 25-35 or over 45 years old. <b>Cat demographics</b> : 30% cats pedigree, 70% random bred or crossbred.</p>	<p>behaviour (e.g. biting and staring) towards humans and conspecifics. <b>Physical environment:</b> Number of litter trays provided.</p>	<p>multiple cats, and 30% other pets. 22% households contained female only cats, 34% male only, with the remainder containing both sexes. 40% households contained a single cat. Average 1.9 cats per household for cats where behavioral data from owners was obtained. <b>Physical environment:</b> 40% households kept cats strictly indoors, with the remaining having varying levels of indoor/outdoor access.</p>	<p>of timidity/confidence, rated on 5 point scale. Owner reported incidences of cat aggression (e.g. biting and staring) towards conspecifics and humans, frequency of cats eating and sleeping together, resource blocking and house soiling.</p>	<p>event (survey). Some, although not all, questions included several frequency based options as repose variable, although no observation time period specified.</p>	<p>s between survey variables relating to cat acquisition, cat demographic features, behaviour and environmental provisions (e.g. breed and coat colour and cat temperament, types of victims of aggressive behaviour, house soiling and number of litter trays).</p>
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<p>Lichtsteiner &amp; Turner (2008). Influence of indoor-cat group size and dominance rank on urinary cortisol levels<sup>48</sup></p>	<p>Observational, analytic cohort</p>	<p>To determine if differences exist in the basal urinary cortisol levels between cats housed singly, and 'omega' and 'alpha' cats from within multi-cat households, across variations in environmental and human-social parameters, and between cats from private households versus cats within shelters</p>	<p><b>Subjects:</b> 17 owners and cats in Switzerland originally recruited via letter and questionnaire. <b>Owner demographics:</b> None other provided. <b>Cat inclusion criteria:</b> Healthy, neutered cats aged between 1-14 years, from one, three or four cat households, kept strictly indoors. <b>Cat demographics:</b> Average age 5, 20 male and</p>	<p><b>Social environment:</b> Number and density of cats per household, number and density of humans per household, number of humans per cat. 'Dominance ranking' (from 'alpha' to 'omega') calculated via relative order of cats to approach food and toys during 'competition trails' and their associated scores. <b>Physical environment:</b> Size of household (m<sup>2</sup>).</p>	<p><b>Social environment:</b> 6 cats from single cat households and 12 cats from multi-cat households (2 'dominant-subordinate' pairs per household). Number of adults per household measured, although relevant descriptive statistics not clearly indicated. <b>Physical environment:</b> All strictly indoors. Space available to cat measured although relevant descriptive statistics not clearly indicated.</p>	<p>Urinary cortisol to creatinine ratios analysed from excreted samples.</p>	<p>6 urine samples collected per cat, one sample per day (or whenever possible for multi-cat groups). Averaged cortisol value from multiple samples used in main analysis. 10, 3 minute competition trails per trail type (i.e. food/toy), presumably conducted over several days to generate</p>	<p>Wilcoxon signed rank and Mann Whitney U tests using to determine differences in urinary cortisol ratios between 'dominant' and 'subordinate' cats within households, and between cats in single and multi-cat households. Spearman rank correlation</p>
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			20 female cats from 17 households originally recruited, then reduced to 18 cats from 12 households (5 males, 13 females) due to data collection issues.				cumulative score for ranking.	used to assess relationship between cortisol, cat age, and environmental parameters.
Amat M et al (2009). Potential risk factors associated with feline behaviour problems <sup>51</sup>	Observational analytic, retrospective with randomised controls	To describe the most common behaviour problems in a feline population referred to a behavioural clinic and to identify risk factors (for behaviour problems) on	<b>Subjects:</b> 336 owners and cats in Spain presented at the Animal Behaviour Service in Veterinary Teaching Hospital between 1998-2006. 189 cats randomly	<b>Social environment:</b> Cat social behaviour, elimination habits, daily activities, training. <b>Other:</b> Nutrition.	<b>Social environment:</b> None provided. <b>Physical environment:</b> For test cats 86% were indoor-only. For control cats 64.6% were indoor-only.	Owner reported behaviour concerns: aggression, inappropriate elimination, compulsive behaviour, excessive vocalisation, fears or phobias,	Data collected from single sampling events from 336 case cats presenting at the Animal Behaviour Service between 1998-2006. 189 control cats	Chi <sup>2</sup> test used to identify significant relationships between behaviour problems and cat characteristics.

		<p>which preventive measures should be based</p>	<p>selected from the hospital database from same time period to act as controls.</p> <p><b>Owner demographics</b> : None other provided. <b>Cat demographics</b> : Case cats - 59% from multi-cat households, 53% female, average age 4.5 years, 24% purebred. Control cats - 65.8% from multi-cat households, 49.7% female, average age 4.9 years,</p>			<p>anorexia, furniture scratching. Specific information - beginning and evolution of problem, context of it occurring. For aggressive cats additionally target and body posture.</p>	<p>randomly-selected from the hospital database from same time period.</p>	
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			21.69% purebred.					
Ramos et al (2012). Factors affecting faecal glucocorticoid levels in domestic cats ( <i>Felis catus</i> ): a pilot study with single and large multi-cat households 49	Observational, analytic cohort	To investigate faecal glucocorticoid metabolites in single and multi-cat households in order to compare arousal levels, and to explore the possible influence of owner's subjective quality of life on cat arousal states.	<b>Subjects:</b> 20 owners of 30 cats in Brazil from 14 single (n=14) and 6 multi-cat (n=16) households, recruited from university staff members within veterinary medicine department and from vet clinic clients. <b>Owner demographics</b> : None other provided. <b>Cat demographics</b> : Single cats - 6 male and 8 female	<b>Social environment:</b> Owner self-reported quality of life, across various dimensions e.g. physical, social, physiological, environmental (WHOQOL-bref). <b>Physical environment:</b> None mentioned.	<b>Social environment:</b> Multi-cat households contained broad range of group sizes from 7 and 48 cats. <b>Physical environment:</b> None provided.	Faecal glucocorticoid metabolites analysed from excreted samples.	4 excreted faecal samples collected per cat over the course of 1 week. Averaged value presumably used in statistical analysis although not specified.	Student's T-test used to detect differences in faecal cortisol levels between single and group housed cats. Multiple regressions were used to assess the effect of age, gender, breed and neuter status on cortisol concentrations, as well the effects

			neutered cats, including nine mixed breed and 3 pedigrees, average age 4.6 years. Multi-cat - 5 male and 11 female cats, 9 neutered and 7 entire, including 8 mixed breed and 8 pedigrees, average age 6.3 years.					of owner quality of life and living style (single versus multi) and their interaction on cortisol.
Ramos et al (2013). Are cats ( <i>Felis catus</i> ) from multi-cat households more stressed?	Observational, analytic cohort	To compare general arousal levels in cats housed singly and in multi-cat households as a function of owner	<b>Subjects:</b> 60 owners of 120 cats in Brazil recruited via adverts in veterinary clinics in Sao Paulo City. <b>Owner</b>	<b>Social environment:</b> Owners categorised cats as bossy, timid or easy-going. Behavioural history pertaining to	<b>Social environment:</b> No dogs. <b>Physical environment:</b> Indoor-only or access to enclosed yards. No moving, travelling renovation work or change of animals/humans in the house during study.	Faecal glucocorticoid metabolites analysed from excreted samples.	Four faecal samples collected per cat (two cats only gave three samples), ideally on the same	Median GCM levels calculated for each cat. Random effects model used. Inferences based on

Evidence from assessment of faecal glucocorticoid metabolite analysis <sup>50</sup>		defined cat personality and behavioural tendencies	<p><b>demographics</b> : None other provided. <b>Cat inclusion criteria:</b> Any sex but no females in oestrus. No known organic diseases, behavioural problems, current use of medication or planned vet visits. Cats in home for minimum four months prior to study. <b>Cat demographics</b> : 23 single cat households, 20 households with a pair of cats, 17 multi-cat</p>	<p>cat-cat and cat-human interactions given by owner. <b>Physical environment:</b> None mentioned.</p>			<p>weekday each week. Cat's personality assessed by owners twice, one year apart.</p>	<p>the log-GCM to meet normality assumption of residuals. Variables considered as categorical (owner assessment of personality, sex, breed group, neuter status, age group). F-approximation for Wald test statistics used to identify variation. When</p>
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			households with 3-4. Minimum 6 months old. A homogenous distribution of age, sex, breed and neuter status between the three groups. 89.2% neutered, 80.8% cross-breed, 71.7% >2years old, 56.7% female.					nearing significance (less than 0.15), more detailed analysis within groups performed.
Elzerman et al (2019). Conflict and affiliative behavior frequency between cats in	Cross sectional survey with both descriptive and analytic elements	To collect information from cat owners regarding the frequency of conflict and affiliative signs within multi-cat	<b>Subjects:</b> 2492 owners of 6431 cats in the USA from multi-cat groups recruited via social media and flyers distributed at	<b>Social environment:</b> House level incidences of cat conflict (e.g. staring, stalking, chasing, fleeing, hissing, wailing or screaming and tail	<b>Social environment:</b> None provided. <b>Physical environment:</b> 27.14% cats had indoor-outdoor access, 41.4% households less than 1499m <sup>2</sup> , 52.4% 1500-3499m <sup>2</sup> and 4.4% 3500m <sup>2</sup> . 73.8% cats had one plus litter tray per cat, 62.6% had one plus	Owner reported presence of chronic health conditions and behavioural problems. Owner rating	Information extracted from a single sampling event (survey). Some, although not all, questions included	Unsupervised Bayesian network analysis used to visualise interrelationships in data (variables

<p>multi-cat households : a survey-based study<sup>26</sup></p>		<p>groups in order to determine relationship with owner's ratings of cat-cat harmony as well as environmental parameters and cat demographics</p>	<p>vet clinics and conferences.  <b>Owner inclusion criteria:</b> Over 18 years old, owning no more than four cats and four dogs.  <b>Owner demographics</b> : 94% female.  <b>Cat demographics</b> : 17.58% cats declawed, 48.75% female, average household ages - 6.09% less than 1 year, 45.47% 7-12 years, 16.21% over 12 years.</p>	<p>twitching), affiliative (nose-touching, sleeping in the same room, sleeping while touching and allogrooming) and overall social harmony (owner rating) assessed via adapted Oakland Feline Social Interaction Scale (OFSIS), DePorter et al 2019<sup>91</sup>, based on owner ratings of frequency and intensity of behaviours. Order of introduction of cats to</p>	<p>feeding station per cat, 61.8% had one plus scratching post per cat.</p>	<p>of cat on 'active and curious' and 'shy and sedentary' scale.</p>	<p>several frequency based options as response variable, although no observation time period specified.</p>	<p>unspecified) . Spearman's correlation tests used to assess relationships between frequencies of conflict and affiliative behaviour and Spearman's correlation tests and Chi<sup>2</sup> to assess the relationship between behaviour frequencies and owner rating of cat harmony, and</p>
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			15.45% chronic health issue. 16.75% living in house 6 months - 2 years, 77.51% more than 2 years.	household. <b>Physical environment:</b> Size and type of house, quantity and location of litter boxes, feeding stations and scratching posts.				between behaviour and household parameters, with corrections applied for multiple testing.
Barcelos et al (2018). Common Risk Factors for Urinary House Soiling (Periuria) in Cats and Its Differentiation: The Sensitivity and Specificity of	Cross sectional survey with analytic elements and control population	To quantify significance of a range of potential risk factors associated with house soiling (marking, latrine and urinary house soiling in general) and to determine the sensitivity (probability of a positive	<b>Subjects:</b> 245 responses from owners and cats globally. Brazil (78, 31.8%), UK (47, 19.2%), Portugal (22, 9.0%), USA (19, 7.8%) and Australia (11, 4.5%) with 20 (8.2%) from other countries and 48 (19.6%)	<b>Social environment:</b> Presence of other cats or dogs, presence of other cats outdoors, and inter-cat antagonism indoors and out. Cat's perceived demeanour and relationship with owner e.g. attachment, separation anxiety and	<b>Social environment:</b> Control cats - 42.5% multi-cat, 57% single. Marking cats - 82.5% multi-cat, 17.5% single. Latrine cats - 63% multi-cat, 37% single. <b>Physical environment:</b> Control cats - 50.4% indoor-only, 33.6% restricted outdoor access, 14.2% free access, 17.7% had cat flap. Marking cats - 40% indoor-only, 27.5% restricted outdoor access, 32.5% free access, 37.5% had cat flap. Latrine cats -	Owner reported presence of periuria (e.g. marking and latrine problems), owner perceived cat demeanour (e.g. clingy versus affectionate, nervous or easily frustrated),	Information extracted from a single sampling event (survey). Frequency of periuria i.e. once daily/weekly/monthly/yearly.	Univariate tests of association; Chi2, Mantel-Haenszel common odds ratio estimate, Spearman's rank, and difference; Kruskal-Wallis and Mann Whitney, to identify risk

Common Diagnostic Signs <sup>28</sup>		diagnosis) and specificity (probability of absence of the sign correctly excluding the diagnosis) of specific signs traditionally related to the different forms of house soiling	unknown. <b>Owner demographics</b> : None other provided. <b>Cat demographics</b> : Cats ranged from 6 months to 19 years (mean 6.3 years). 51% male. 93.5% neutered. 84.9% mixed breed.	aggression towards family members. <b>Physical environment:</b> Litter tray details e.g. location, number of trays, tray type and size, litter type including scented (y/n), litter liners, cleaning frequency and cleaning products used, outdoor access.	68.5% indoor-only, 19.6% restricted outdoor access, 12% free access, 13% had cat flap.	medical history.		factors for periuria and latrine problems from variables including cat features, household features, personality and specific toileting behaviours.
Grigg & Kogan (2019). Owners' attitudes, knowledge, and care practices:	Cross sectional survey with both descriptive and analytic elements	To measure the attitudes, knowledge of behaviour, environmental needs and current trends in cat care	<b>Subjects:</b> Owners of 547 cats in the USA recruited via online marketplace survey platform	<b>Social environment:</b> Number of cats, humans, children and dogs per household, owner	<b>Social environment:</b> Multi-cat group sizes ranged from 1-11 (mean 1.8), 58% respondents lived in single-cat homes, 26% 2 cats and 16% 3 or more. Adults per household ranged from 1-	Owner reports of whether cat was declawed, behaviour problems exhibited by	Information extracted from a single sampling event (survey). Presence of behaviour	Spearman's rank order correlations, Mann-Whitney U, Kruskal-Wallis and Chi <sup>2</sup>

<p>Exploring the implications for domestic cat behavior and welfare in the home<sup>45</sup></p>		<p>amongst US cat owners</p>	<p>offering respondents small participation fee. <b>Owner inclusion criteria:</b> 18+ years or older currently owning a cat between 1 -18 years. <b>Owner demographics</b> : 39.1% male, 60.3% female with a mean age of 38.0 (±11.5) years. 93.6% been living with cat for at least 1 year. <b>Cat demographics</b> : 45% cats spayed females, 39% neutered</p>	<p>knowledge (determined via responses to various cat-based questions), cat owner relationship (measured via items taken from cat-owner relationship scale, CORS Howell et al 2017). <b>Physical environment:</b> Outdoor access and time spent outdoors, basic environmental provisions, for some, amount per cat and location.</p>	<p>5 (average 2.1), 18% single adult, 62% 2 adults, 14% 3 adults and 6.4% 4 or more. Children per household ranged from 1-6 (average 1.7), 60% no children, 20% 1 child, 14% 2 children, 6.2% 3 or more. Average 1.8 dogs per household, 46% no dogs, 35% 1 dog, 14% 2 dogs, 4.4% 3 or more. Most cats (47.7%) cats played with daily, fewest cats (3.8%) never played with. Most (20.3%) of cats with outdoor access spent 1-2 hrs outdoors, fewest cats (2.6%) spent 5-6 hrs outdoors. Most (30.7%) cats spend 5-8hrs without humans, fewest (4.2%) spent &gt;12 hours. <b>Physical environment:</b> 60% cats kept strictly indoors. Average 1.7 litter trays/cat, 1 feeding</p>	<p>cat (e.g. aggression to humans/cats, general anxiety, destructive behaviour, repetitive behaviours, housesoiling, vomiting) and the extent they bother the owner (from not at all to a great deal), reports of 'misbehaviour', e.g. destructive scratching or inappropriate elimination (y/n) and how owner responds</p>	<p>problems based on previous 30 day period.</p>	<p>analyses used to assess associations between demographic variables, cat care, behaviour problems and owner bond with cat. Multiple linear regressions then used to determine whether demographic variables, owner attitudes and cat care were predictive</p>
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			<p>males, 8.2% intact males, 7.1% intact females. 76.7% cats not declawed; highest percentage of cats (41%) acquired from shelter.</p>		<p>station. 62.9% owners reported scooping the litterbox(es) one or more times per day. 92.1% owners provided quiet places for cats, 81.3% toys, 68.7% scratching posts, 51.7% climbing/perching area, 6.5% used pheromone products (e.g. Feliway).</p>	<p>(e.g. yell, hit/kick, spray with water, redirect behaviour).</p>		<p>of reported cat behaviour problems.</p>
<p>Lawson et al (2019). The environmental needs of many Australian pet cats are not being met<sup>56</sup></p>	<p>Cross sectional survey with both descriptive and analytic elements</p>	<p>To survey cat-owning population in Australia to investigate the provision of environmental resources in the home and identify factors that may compromise cat welfare</p>	<p><b>Subjects:</b> 12,010 owners of 23,920 cats in Australia recruited via social media and professional networks. One survey per household completed with respondents requested to select answers</p>	<p><b>Social environment:</b> Number of cats per household. <b>Physical environment:</b> Basic environmental provisions (some including amount per cat and location).</p>	<p><b>Social environment:</b> 45.5% respondents lived in single-cat homes, and 54.5% were multi-cat households (range not specified but average of two cats per household). <b>Physical environment:</b> 46.3% of households contained cats with indoor/indoor with restricted outdoor access or had access to outdoor enclosure, 51.8% contained cats with unrestricted access to the</p>	<p>Owner reported frequency of house soiling and urinary problems (straining to urinate, vocalising when urinating, blood in urine, urethral obstruction).</p>	<p>Information extracted from a single sampling event (survey). No time periods specified.</p>	<p>Generalised linear mixed-models used to predict relationships between the presence of urinary problems, lifestyle and environmental variables and</p>

			<p>that best fit the majority of the cats in the household.</p> <p><b>Owner and cat demographics</b> : None other provided.</p>		<p>outdoors and 1.8% had mostly outdoor cats. 98.7% cats have access to low furniture (i.e. bed, sofa) and 81.2% to high furniture (e.g. shelf or wardrobe), 85.3% to window sill, 17% to furniture specifically designed for cats and 64.2% to a cat tower/tree. 92.4% of indoor cat households and 71.2% of indoor-outdoor cats provided scratching posts. 7.3% households used activity/puzzle feeders. 71.3% households provided trays in single location. 80.1% of single-cat households provided one litter tray, 17.7% two trays and 2.2% three or more litter trays. 36.5% of two-cat households provided one tray, 44.7%</p>			<p>relationships between presence of inappropriate urination outside of the litter tray, and lifestyle and environmental variables.</p>
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					<p>two trays and 18.8% three or more litter trays. 16.7% of three cat households provided one litter tray, 32.0% two trays and 51.3% three or more trays. Common locations of litter trays included laundry room, bathroom, hallways and spare bedrooms. 35.6% households removed wet litter tray trays several times weekly. 63.7% households removed faeces from tray after one deposit.</p>			
Roberts et al (2020). Influence of living in a multi-cat household on health and behaviour in a cohort	Observational analytic cohort	To determine associations between single and multi-cat households and measures of cat health and behaviour	<p><b>Subjects:</b> 1150 owners of kittens between 2-4 months in the UK recruited locally and then nationally via adverts in</p>	<p><b>Social environment:</b> Presence/absence of cat-cat conflict in multicat households, amount of playing time (with who/what</p>	<p><b>Social environment:</b> 62.2% of multicat households categorised as 'agonistic', with the other 37.8% as 'non-agonistic'. Multicat group sizes ranged from 2-30 (43% contained 2 cats, 21.2% 3, 10.6% 4, 20.9% 5-9, 3.2% 10-14, 1.1%</p>	Owner reports of cat obesity, cat abscess or bites, periuria and negative interaction with owners. For multicat	Owners completed questionnaires for cats over the following time periods; 2-4 months, 6 months, 12 months, 18	Various univariate and multivariate logistic regressions run to assess associations between cat outcomes

<p>of cats from the United Kingdom<sup>47</sup></p>			<p>vets, rehoming centres and cat website.  <b>Owner demographics</b> : none other provided. <b>Cat demographics</b> : 783 cats considered eligible for inclusion in study comprising cats from single (n=167) and multi-cat households (where cat-cat interactions actually took place n=6161, 1 cat per household). 52.4% male, 23.5% purebreds, 2.8</p>	<p>not specified), neighbourhood cat density, incidents of cat starting in through window and coming in house. <b>Physical environment:</b> Time spent outdoors, presence of garden</p>	<p>15+), with a median of 3.  <b>Physical environment:</b> None provided</p>	<p>groups, the presence or absence of the following cat-cat interactions used to designate agonistic/non-agonistic cat groups: 'hisses or spits at another cat', 'is hissed or spat at by another cat', 'is reluctant to pass another cat in a narrow space' and/or 'blocks or inhibits the movement</p>	<p>months and 2.5 years. Reports of cat bites and periuria were specified as within past 12 months. Not time frame specified for other outcome measures</p>	<p>(obesity, cat bites, periuria and negative interaction with owners), cat housing (single versus multi-cat status and agonistic versus non-agonistic multi-cat groups), and various other demographic factors and environmental parameters</p>
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			<p>cats unneutered. 19.9% cats reported as overweight/obese at 2.5 years old, 8.7% reported to have had an abscess or cat bite in past year, 10.6% reported to have house soiled, 16.9% cats reported to have had negative interactions with owner.</p>			<p>of another cat'. Owner reported presence or absence of following human-directed behaviours used to identify negative interactions with humans: 'runs away', 'growls, hisses or spits' and 'swipes at me'</p>		
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### A3. FELINE LIFESTYLE STUDY

## Feline Lifestyle Study

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### Introduction

Researcher: Rae Foreman-Worsley, Nottingham Trent University

Contact details: [cat.lifestyle.study@gmail.com](mailto:cat.lifestyle.study@gmail.com)

Thank you for your interest in this survey. I am PhD student at Nottingham Trent University studying domestic cats, and the impact lifestyle can have on behaviour and welfare. The survey is split into three parts, with part one being the primary section and the subsequent parts being optional. Part one of the survey is anonymous and has been designed to collect data relating to ownership, care provision and social environment of cats across the globe. It should take approximately 20 minutes to complete. After completion of part one, the subsequent parts will be explained. You can choose to stop and withdraw from the study at any time by closing the browser.

If choosing to opt into further studies an email address will be required, although this is optional. Any contact details provided will be kept confidential and your participation will only be used once any identifying features are removed. The data are anonymous (or will be made confidential if contact details are provided) and cannot be connected to you. Data collected may be used for other research activities, including subsequent publication. All individual response information will be stored on a password-protected system and will only be accessible to the research team. However, if you wish to withdraw you can do so by e-mailing the researcher with your unique participant number (produced later in the survey). By submitting your data at the end of this questionnaire you assent to their use, unless withdrawn. If you withdraw from the study within a week any contributions made to the project will be destroyed and your data removed. After this period, data will be anonymised and prepared for analysis. Therefore, they will be unable to be individually identified and cannot be withdrawn.

If you have any concerns about the questions or content you should contact the project researcher using the e-mail above.

**Please tick to confirm the following:**

- I confirm that I am over the age of 18
- I have read the above information and understand the purpose of this study
- I understand that I can stop and withdraw from this study by following the process outlined above

## Demographics

Before the survey starts, please answer the following questions about yourself.

What is your gender?

- Female                       Male                       Other  
 Prefer not to say

What is your age?

- 17 or under                       18-25                       26-35  
 36-45                       46-55                       56-65  
 66-75                       76+                       Prefer not to say

What is your employment status?

- Employed full-time                       Self-employed                       Unemployed  
 Student full-time                       Student part-time                       Employed part-time  
 Retired                       Other                       Prefer not to say

Which country do you live in?

## Cat ownership

Do you currently have at least one cat?

- Yes  
 No

## Cat demographic

If you have more than one cat, please answer the survey about your cat whose name comes first alphabetically.

What sex is your cat?

- Male  Female  Unknown

Approximately how old is your cat?

Please select ▼

Is your cat pedigree/purebred?

- Yes  No  Unsure

Please indicate which colour best describes your cat.

- Black  White  Tabby  
 Ginger  Grey or blue  Brown  
 Tortoiseshell (black/ginger)  Black/white  Tabby/white  
 Ginger/white  Grey or blue/white  Tortoiseshell/white  
 Cream  Other

What coat length does your cat have?

- No hair  
 Short  
 Medium  
 Long



Is your cat neutered (aka spayed, castrated, desexed or fixed)?

Yes

No

Unsure

Is your cat microchipped?

Yes

No

Unsure

Is your cat up to date with their vaccinations?

Yes

No

Unsure

Is your cat declawed? Please note this does not mean nails have been trimmed, but that a surgical procedure has been completed to remove the claws entirely.

Yes

No

Unsure

## Cat health and behaviour

Does your cat have any ongoing medical conditions?

- Yes (please detail below)  
 No

This part of the survey uses a table of questions. [view as separate questions instead?](#)

Please indicate how often, if ever, your cat displays any of the following:

	Never	Rarely	Sometimes	Often	Always
Elimination problems (urinating/defecating in inappropriate places)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vomiting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diarrhoea	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Constipation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scratching furniture	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Spraying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Excessive vocalisation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggression towards owner	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggression towards strangers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Overgrooming	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hiding at unexpected noise (knock on door, noise outside)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please indicate how you would best describe your cats personality on the scales below:

	0	1	2	3	4	5	6	7	8	9	10	
Calm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Energetic
Timid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Confident
Solitary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Social
Indifferent	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Curious
Submissive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Dominant
Passive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Aggressive

## Cat lifestyle

What lifestyle does your cat have?

- Outdoor only - cat lives outdoors at all times and does not come into the house  
 Indoor/outdoor - cat has access to home and outside space  
 Indoor only - cat lives indoors at all times and does not go outside

## Outdoor Access

You have previously indicated that your cat spends time outdoors. Over the past month, please indicate how long your cat typically spends outside ...

... on a weekday?

Please select 

... on a weekend?

Please select 

This part of the survey uses a table of questions. [view as separate questions instead?](#)

Please indicate how often the following scenarios occur:

	Never	Rarely	Sometimes	Often	Always
Your cat comes in from outside with evidence of fighting (scratches, bleeding, fur missing)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
You see cats that are not yours in your garden	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
You hear cats fighting from your home	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cats you do not own enter your home	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Indoor-only

You have previously indicated that your cat has an indoor-only lifestyle. What are the reasons for this? Please select all that apply and leave as many details below as possible.

- Cat's choice - cat won't go outside even with door open
- Live in flat/apartment so no outdoor access
- Owner's choice
- Other

If you selected Other, please specify:

## Home environment

You have previously indicated that your cat spends either all or a portion of its time inside. Please provide a few details about your home below.

What type of house do you live in?

- Flat/apartment
- Studio flat/apartment
- Terrace
- Semi-detached
- Detached
- Bungalow
- Motorhome
- Other

Which type of area best matches the area you live in?

- |                                   |                             |                                |
|-----------------------------------|-----------------------------|--------------------------------|
| <input type="radio"/> City centre | <input type="radio"/> Urban | <input type="radio"/> Suburban |
| <input type="radio"/> Village     | <input type="radio"/> Rural | <input type="radio"/> Other    |

How many rooms does your house have?

Within your home, how many rooms does your cat have access to?

## Provision

This part of the survey uses a table of questions, [view as separate questions instead?](#)

Please indicate how many of the following items you have INDOORS, IN TOTAL and if these items are available at all times. (Please note, if you have four food bowls and four cats, therefore one bowl per cat, please still respond with the total, 'four'). Please select all that apply.

	How many of these items does your cat have?						Are these items available to your cat at all times?			
	0	1	2	3	4	5+	Yes	No	Some	NA
Manual toys requiring owner interaction e.g. dangles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Independent toys your cat can play with alone e.g. balls, mice, track toys or electronic toys	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scratching items e.g. post/pad	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hiding areas e.g. igloo/tent, cardboard box	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cat bed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vertical enrichment e.g. cat tree, shelves on wall	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cat grass e.g. grass grown in a container for the cat to chew	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water bowls	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water fountain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Food bowl	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeding enrichment e.g. puzzles/activity feeder, treat ball	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Litter trays e.g. covered, uncovered	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Social environment - adults

How many people aged 18 and over live in your household?

This part of the survey uses a table of questions, [view as separate questions instead?](#)

Please indicate approximately how often **ADULTS** in the household do the following activities with your cat.

	Never	Less than monthly	Monthly	Every two weeks	Weekly	Twice weekly	Daily	Twice daily	More than twice daily
Playing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Petting/stroking (without comb/brush/mitt)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Grooming (with comb/brush/mitt)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Holding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting with (cat on lap)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting with (next to cat)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training the cat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please indicate approximately how often your cat does the following with **ADULTS** in the household.

	Never	Less than monthly	Monthly	Every two weeks	Weekly	Twice weekly	Daily	Twice daily	More than twice daily
Runs away from/avoids	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hisses at	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scratches/attacks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

On an average day, how many hours is your cat left alone without people in the house?

Do you have anyone 17 and under in your home?

Yes  
 No

## Social environment - children

This part of the survey uses a table of questions, [view as separate questions instead?](#)

Please indicate approximately how often CHILDREN UNDER 17 in your household do the following activities with your cat.

	Never	Less than monthly	Monthly	Every two weeks	Weekly	Twice weekly	Daily	Twice daily	More than twice daily
Playing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Petting/stroking (without comb/brush/mitt)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Grooming (with comb/brush/mitt)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Holding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting with (cat on lap)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting with (next to cat)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training the cat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

This part of the survey uses a table of questions, [view as separate questions instead?](#)

Please indicate approximately how often your cat does the following with CHILDREN in the household.

	Never	Less than monthly	Monthly	Every two weeks	Weekly	Twice weekly	Daily	Twice daily	More than twice daily
Runs away from/avoids	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hisses at	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scratches/attacks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Social environment - other cats

Do you own any other cats who live with the cat you are answering this survey for?

Yes

No



## Social environment - other cats

You previously indicated that you have more than one cat. How many cats do you have in your home in total (including the cat you are answering this survey about)?

This part of the survey uses a table of questions. [view as separate questions instead?](#)

You have previously indicated that you have more than one cat. Please indicate how often the cat you are answering this survey for does any of the following activities with the other cats in the household.

	Never	Less than monthly	Monthly	Every two weeks	Weekly	Twice weekly	Daily	Twice daily	More than twice daily
Grooms the other cat(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Be groomed by the other cat(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Runs away from/avoids	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Play fights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Play with toys together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sleep together (touching)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sleep near each other (less than 50cm/2 foot)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Growl/hiss at other cat(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Be growled/hissed at by other cat(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Social environment - dogs

Do you own a dog who lives with the cat you are answering this survey for?

Yes  No

## Social environment - dogs

You previously indicated that you have a dog. How many dogs do you have in your home?

This part of the survey uses a table of questions. [view as separate questions instead?](#)

You have previously indicated that you have a dog. Please indicate how often the cat you are answering this survey for does any of the following activities with the dogs in the household.

	Never	Less than monthly	Monthly	Every two weeks	Weekly	Twice weekly	Daily	Twice daily	More than twice daily
Grooms the dog(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Be groomed by the dog(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Runs away from/avoids	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Play fights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Play with toys together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sleep together (touching)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sleep near each other (less than 50cm/2 foot)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Growl/hiss at dog(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Be growled/barked at by dog(s)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## End of part one

Thank you for completing part one of the survey. If you are interested in hearing about the results, please leave your email address below. The email address will be kept confidential and data used will be anonymised before use.

Part two of the study will ask you to provide a hair sample from your cat. If you are willing to do so please continue below.

Email address: *Optional*

Please indicate if you would like to end the survey now or provide a hair sample for your cat. This hair will be processed in the laboratory to test the levels of the hormone called cortisol it contains. In many species, cortisol has been shown to be an indicator of stress and we wish to examine this in cats. **Please do not close the browser without submitting as your response will be lost.** \* *Required*

- Provide hair sample
- End and submit answers

## Participation in part two

For part two of the study we are asking cat owners to send us a small sample of their cat's hair. This hair will be processed in the laboratory to test the levels of the hormone called cortisol it contains. In many species, cortisol has been shown to be an indicator of stress and we wish to examine this in cats. If you are interested in participating in this part of the study, please complete the additional questions below before following the instructions. Please note that if you do not complete these questions now you will be unable to participate later.

How often do you shampoo your cat? *Optional*

- |                                       |  |                                  |
|---------------------------------------|--|----------------------------------|
| <input type="radio"/> Daily           | <input type="radio"/> 2-3 times a week | <input type="radio"/> Weekly     |
| <input type="radio"/> Every two weeks | <input type="radio"/> Monthly          | <input type="radio"/> Less often |
| <input type="radio"/> Never           |  |                                  |

Please provide a unique reference ID below by using the first half of your post code, followed by the first three letters of your cats name, followed by the last two digits of your phone number. Please ensure this number is included with the sample you send so we can match your survey responses to your cat's hair sample. *Optional*

### Instructions on how to collect and send the hair sample.

Hair should be provided from the cat you have answered this survey for, not another cat in the household or multiple cats.

Hair should be cut or clipped from the hip/thigh of the cat using scissors or clippers, as close to the skin as possible without causing injury. Please see the photo below for where hair should be taken from. Hair should NOT be plucked or pulled as not only will this cause distress to your cat but it will mean the sample cannot be used.

Note: Please take care when cutting the hair from your cat, and only do so if the cat is relaxed and comfortable. Any cat who is frightened or anxious may be at increased risk of injury from sharp objects, as may the handler.

Once collected, hair should be contained (within a plastic bag, tin foil, cling film etc.), placed in an envelope with the unique code you have generated and sent to the following address:

NB. In the address above, the 'XXXXXXXX' should be replaced by the unique reference ID you have provided to ensure hair samples and survey responses can be paired. If the unique ID number is not provided unfortunately it will not be possible to process the sample.



Image from pixabay.com

Please indicate below that you have read and understood the following information: *Optional*

- The hair should be labelled with the unique reference ID you have provided to ensure hair samples and survey responses can be paired. If the unique ID number is not provided unfortunately it will not be possible to process the sample.
- You are free to opt out of this stage of the study at any time.

### Part three - additional studies

Many thanks for completing this much of the survey, your responses are greatly appreciated.

In addition to the online survey, we hope to complete further studies regarding cat lifestyle and welfare. To do so, we are looking for participants willing to take part in activities such as focus groups or activity studies. If you would be willing to be contacted about participation in these studies, please provide your email address below. If contacted, you will still have the option to decline participation and you can withdraw your email address at any time by emailing the project researcher.

If you do not wish to participate in these sorts of studies, please click next to continue to the final part of the study.

Email address:

Please enter a valid email address.

## Part four - FeBARQ (optional)

Please ensure you **CLICK FINISH** below to **SUBMIT** your survey otherwise responses will be lost (whether participating in the FeBARQ or not).

If participating in the FeBARQ survey, please open the link in a **NEW BROWSER**.

The final part of the study is a further optional questionnaire, called FeBARQ, about your cats' behaviour and personality.

To link the answers of this study to the FeBARQ study you will need to provide the unique ID provided in the previous section when registering on the FeBARQ site. Failure to do so will mean responses cannot be used.

If you did not generate a unique ID previously then please do so below.

If you wish to complete this section later, please follow the link below and save it for a later date, then click next below to end this survey.

Please note, the questionnaire requires cats to be at least 6 months old, and so if you have a kitten under six months you will be unable to complete the questionnaire.

Please provide a unique reference ID below by using the first half of your post code, followed by the first three letters of your cats name, followed by the last two digits of your phone number. *Optional*

Your answer should be no more than 9 characters long.

Please follow the link to access the FeBARQ site.

<http://vetapps.vet.upenn.edu/febarq/>

The name of the study is 'Feline Lifestyle Research'.

An access code will also need to be provided. This is as follows:

344467

**End**

Thank you for your interest in participating in this survey. Due to the nature of the study we have specific inclusion criteria for respondents which unfortunately at this time you do not meet. If you wish to help us in other ways, please share this study on social media to help increase the number of responses we receive, and thank you again for your interest.

## End

Your responses to this survey have been submitted.

If you need a formal record of your submission, please use the following details:

### Completion receipt

Receipt number: 1-1-1  
Submission time: 2022-04-01 13:56:45 BST

 [Print](#)  [Download PDF](#)  [Email](#)

Many thanks for completing this survey. Your responses will help towards improving our knowledge on feline welfare. If it is possible for you to share this survey through social media to increase the numbers of responses obtained it would be greatly appreciated.



## A4. FELINE LIFESTYLE STUDY – INDOOR RATIONALE SURVEY

### Feline Study - Indoor rationale

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#### Introduction

Researcher: Rae Foreman-Worsley, Nottingham Trent University

Contact details: [cat.lifestyle.study@gmail.com](mailto:cat.lifestyle.study@gmail.com)

Thank you for choosing to participate in this study following your previous involvement in my cat lifestyle study.

Your email address will be required in order to connect your previous response to your answers from this survey. Any contact details provided will be kept confidential and your participation will only be used once any identifying features are removed. The data are anonymous (or will be made confidential if contact details are provided) and cannot be connected to you. Data collected may be used for other research activities, including subsequent publication. All individual response information will be stored on a password-protected system and will only be accessible to the research team. By submitting your data at the end of this questionnaire you assent to their use, unless withdrawn. If you withdraw from the study within a week any contributions made to the project will be destroyed and your data removed. After this period, data will be anonymised and prepared for analysis. Therefore, they will be unable to be individually identified and cannot be withdrawn.

If you have any concerns about the questions or content you should contact the project researcher using the e-mail above.

#### Email

1. Please enter the email address you used for the previous survey AKA the email address where you received the invitation for this survey. This will enable your answers to this survey to be matched with your previous answers. \* *Required*

#### Indoor management

2. In the previous survey you indicated that your is indoor-only, is this correct/still correct? \* *Required*

Yes

No

## Indoor rationale

3. You have previously indicated that your cat has an indoor-only lifestyle. What are the reasons for this? Please select all that apply and leave as many details below as possible.

- Cat's choice - cat won't go outside even with door open
- Live in flat/apartment so no outdoor access
- Owner's choice
- Other

- a. If you selected Other, please specify:

## Indoor-outdoor consideration

4. Before choosing an indoor-only lifestyle for your cat did you consider giving you cat an indoor-outdoor lifestyle? \* Required

- Yes, I did consider an indoor-outdoor lifestyle
- No, I did not consider an indoor-outdoor lifestyle

5. If you were to have an indoor-outdoor cat, please indicate what the major reason for this would be. \* Required

- Potential benefit to my cat's mental health
- Potential benefit to my cat's physical health
- To toilet outside
- To controls pests (e.g. mice) through hunting
- Cat indicates they want to go outdoors
- Other

- a. If you selected other, please specify:



## Indoor-outdoor concerns

This part of the survey uses a table of questions, [view as separate questions instead?](#)

6. Please indicate to which extent you feel the following factors are a concern for an indoor-outdoor cat.

	No concern	Weak concern	Some concern	Moderate concern	Strong concern
Outdoors is detrimental to my cats mental health	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outdoors is detrimental to my cats physical health	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cat toileting outside	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cat hunting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- a. If you answered 'other' please provide details below:

7. If you have any other comments regarding letting cats roam freely outdoor please leave details below:




## End

Your responses to this survey have been submitted.

If you need a formal record of your submission, please use the following details:

### Completion receipt

Receipt number: 1-1-1  
Submission time: 2022-04-01 17:42:44 BST

 [Print](#)  [Download PDF](#)  [Email](#)

Many thanks for completing this survey. Your responses will help towards improving our knowledge on feline welfare. :) I will be in touch with the results of the surveys when they are available.

## A5. FELINE LIFESTYLE STUDY – OUTDOOR RATIONALE SURVEY

### Feline Study - Outdoor rationale

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#### Introduction

Researcher: Rae Foreman-Worsley, Nottingham Trent University

Contact details: [cat.lifestyle.study@gmail.com](mailto:cat.lifestyle.study@gmail.com)

Thank you for choosing to participate in this study following your previous involvement in my cat lifestyle study.

Your email address will be required in order to connect your previous response to your answers from this survey. Any contact details provided will be kept confidential and your participation will only be used once any identifying features are removed. The data are anonymous (or will be made confidential if contact details are provided) and cannot be connected to you. Data collected may be used for other research activities, including subsequent publication. All individual response information will be stored on a password-protected system and will only be accessible to the research team. By submitting your data at the end of this questionnaire you assent to their use, unless withdrawn. If you withdraw from the study within a week any contributions made to the project will be destroyed and your data removed. After this period, data will be anonymised and prepared for analysis. Therefore, they will be unable to be individually identified and cannot be withdrawn.

If you have any concerns about the questions or content you should contact the project researcher using the e-mail above.

#### Email

1. Please enter the email address you used for the previous survey AKA the email address where you received the invitation for this survey. This will enable your answers to this survey to be matched with your previous answers. \* *Required*

#### Indoor-outdoor management

2. In the previous survey you indicated that your cat has some outdoor access, is this correct/still correct? \* *Required*

- Yes  
 No

## Indoor-outdoor rationale

This part of the survey uses a table of questions, [view as separate questions instead?](#)

3. Please indicate if any of the following had an influence on your decision to provide your cat with an indoor-outdoor lifestyle, and to what extent.

	No influence	Weak influence	Moderate influence	Some influence	Strong influence
Outdoors is beneficial to my cats mental health	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outdoors is beneficial to my cats physical health	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cat toilets outside	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cat controls pests (e.g. mice) through hunting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cat indicates they want to go outdoors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- a. If you answered 'other' above, please provide details of what this reason/these reasons are:

4. Which of these reasons had the strongest influence on your decisions to provide an indoor-outdoor lifestyle for your cat? \* *Required*

- Outdoors is beneficial to my cats mental health
- Outdoors is beneficial to my cats physical health
- Cat toilets outside
- Cat controls pests (e.g. mice) through hunting
- Cat indicates they wants to go outdoors
- Other

5. If there are any more details you could provide regarding your choice to provide your cat with an indoor-outdoor lifestyle please leave them below:

## Indoor consideration

6. Before choosing an indoor-outdoor lifestyle for your cat did you consider giving you cat an indoor-only lifestyle? \* *Required*

- Yes, I did consider an indoor-only lifestyle
- No, I did not consider an indoor-only lifestyle

7. If you were to keep your cat indoor-only, please indicate what the major reason for this would be. \* *Required*

- To protect wildlife/prevent cat from hunting
- Protection from people
- Protection from traffic
- Protection from other cats
- Protection from wildlife
- Cat has health issues
- Other

## Indoor-outdoor concerns

This part of the survey uses a table of questions. [view as separate questions instead?](#)

8. Please indicate to which extent you feel the following factors are a concern for an indoor-outdoor cat.

	No concern	Weak concern	Some concern	Moderate concern	Strong concern
Harm to wildlife through hunting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Harm from people	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Harm from traffic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Harm from other cats	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Harm from wildlife	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Health issues	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## End

Your responses to this survey have been submitted.

If you need a formal record of your submission, please use the following details:

### Completion receipt

Receipt number: 1-1-1  
Submission time: 2022-04-01 17:43:03 BST

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Many thanks for completing this survey. Your responses will help towards improving our knowledge on feline welfare. :) I will be in touch with the results of the surveys when they are available.