‘Understanding the approach taken to ageing dogs in primary veterinary care using mixed-methods health informatics’

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Abstract

The UK pet dog population is living longer. This raises concerns for health, welfare, and quality of life due to old age associated health issues. Implementing preventive healthcare at appropriate points throughout life stages may reduce prevalence, or delay onset, of diseases. It is paramount to identify common issues and pinpoint when they occur in order to know when to apply such preventive measures, and the signs to look out for in the case of occurrence. However, varying definitions of the age at which a dog may be considered as old age makes comparisons between studies difficult.

In this study an alternative approach was taken to identify the old age life stage in dogs according to the opinion of veterinarians as recorded within electronic health records (EHRs). The project aimed to determine when veterinary professionals consider a dog to have reached old-age, to identify common issues in old-age dogs, and to investigate preventive healthcare and treatment advice given. This entailed developing regular expressions based on five words associated with old age; ageing, elderly, geriatric, senior and old. These old age dog regular expressions (OAD REs) identified relevant consultations of old age animals which were analysed to identify common reasons recorded within EHRs for presenting to practice. The median age of OAD consultations was 12.5y. The age at which OAD REs were used by veterinarians significantly differed by breed; for example, the Cocker Spaniel was described as reaching old age at 11.7y in comparison to the Jack Russell Terrier which was described as reaching old age at 14.1y.

In order to determine the most common reason for dogs presenting in old age, 832 consultations with OADs were read and classified according to a modified scheme based on the WHO ICD-10. This identified the five most common categories and sub-categories as dental (254 of 832 consultations, 30.5%), digestive (187, 22.5%), integument (235, 28.2%), musculoskeletal (278, 33.4%) and weight (289, 34.7%). Dental and musculoskeletal issues occurred in older animals than the other most common issues at 13.0y ($P<0.05$). Jack Russell Terriers were found to experience musculoskeletal and dental issues later when compared to the other most common breeds ($P<0.01$ and $P<0.05$ respectively). When the three over-arching categories of common issues were further sub-categorised, the most common sub-categories were: tartar (110 of 832 consultations, 4.8%), weight loss (92, 4.0%), and stiffness (60, 2.6%).

In the final part of this thesis, tartar was investigated in further detail in order to identify prevalence and dog types most at risk, as well as what conversations were conducted about preventive healthcare and treatment options. This was achieved by developing a regular expression to extract relevant EHRs, and multivariable modelling compared cases with controls. For each dog-year of age, the risk of tartar increased by 10%, with the Yorkshire Terrier and Cocker Spaniel having higher odds ($P<0.01$). Intact males were least likely to have tartar ($P<0.001$). The clinical narrative from 100 consultations with dogs with tartar were qualitatively analysed to summarise the recorded conversation around prevention and treatment advice. Fifty five percent of dogs identified as having a tartar issue had no evidence of advice or treatment recommendations recorded, 38% were offered advice, and 11% received treatment for tartar issues. Ultimately, the results highlight a need to increase awareness of this common old age associated issue.

Owners should be made aware of when their dog may experience the onset of old age, and the increased risk of old age associated issues according to their breed or breed group and weight, in comparison to other dog types. Future work investigating why particular dog types are perceived by veterinarians to exhibit signs of old age later or have less of a risk of common old-age associated issues, may facilitate an understanding of how to delay the onset of old age and occurrence of common issues. By understanding when a dog reaches old age, the common issues associated with old age, and dog types most at risk of certain issues, targeted health messaging can facilitate increasing awareness amongst owners and veterinary professionals, and improve dog welfare and quality of life.

Contents

Chapter One: Introduction

This chapter is a review of relevant literature surrounding dog ageing, including why it is important to research this area for the welfare of old age dogs; a background on clinics offered for "senior" pets; current approaches to defining old age in dogs; common issues in old age dogs and dog types at increased risk; and the implications this has for human-animal interaction between dogs and their owners.

1.1 The needs of dogs that live longer

Pet dogs are living longer, and so research aiming to ensure the adequate welfare and quality of life of older dogs is increasingly important, as their population accounts for 30-40% of patients seen in practice in the USA for example (Metzger 2005). Our pet dogs may be living longer due to improved healthcare and diets (Grimm, 2015). There have been recent life tables from different countries produced, which may demonstrate whether the same observation has been found in different locations, and whether it is the same for all breeds. For example, in a UK based study of 30, 563 dogs between 2016-2020, life expectancy at age 0y was 11.2y. This varied by breed, with Jack Russell Terriers life expectancy at 12.72y, and French Bulldogs at 4.53y (Teng et al., 2022). In Japan, life expectancy of 12,039 dogs between 2012-2015 was 13.7y (Inoue et al., 2018). Differences in life expectancy of dogs in different countries may be attributed to the types of breeds which are popular within each country. For example, small or toy breeds are more common in Japan, and larger breeds more common in the UK than in Japan, and smaller dogs may live longer than larger dogs (O'Neill et al., 2013; Inoue et al., 2018; Urfer et al., 2020). With ageing comes age-associated issues affecting a number of body systems and, as such, a change in healthcare needs as the dog progresses through this life stage (Neilson et al. 2001; Willems et al. 2017). For example, old dogs are more often considered to be unhealthy and require medication (Wallis et al. 2018) which is a welfare concern. For example, common issues in old age dogs may include degenerative disorders such as

osteoarthritis, skin masses, and heart murmurs (O'Neill et al., 2021). It is, therefore, crucial to identify effective methods for recognising these age-related health needs, to ensure appropriate healthcare provision so that the welfare of this ageing population is not compromised and their quality of life is maintained. This may be achieved through offering a healthcare programme specifically aimed at the ageing dog population (Fortney 2012). As such, an effective tool which can be utilised by veterinary practices and owners to highlight common issues in old-aged dogs would be useful. It could raise awareness of the signs to look out for to ensure owners seek timely medical intervention, as well as guiding discussions around preventive healthcare and optimum treatment recommendations. To create such a tool, knowledge of the common issues facing old age dogs in veterinary practice is required.

1.2 Senior clinics

Preventive healthcare consultations are performed separately to those in which an animal is presented for a specific concern and allows for owners and veterinarians to implement strategies to prevent or prolong the onset of common issues (Robinson et al. 2016). They may also provide opportunities for a veterinarian to highlight and address issues of a patient which an owner may not have otherwise presented their pet to practice for (Robinson et al. 2016). Senior screening health checks may also assist in identifying issues which may otherwise go undetected by owners (Dell'Osa & Jaensch 2016), and provide a reference against which to compare a dog's future health status and whether it has deteriorated at a later consult (Davies 2012). Currently, senior healthcare screenings and healthcare plans are offered in some UK veterinary clinics. However, the effectiveness of such preventive screenings and plans is unknown (Robinson et al. 2016). There are various forms of healthcare clinics for senior dogs, but all aim to improve the quality of life of an ageing animal (Fortney 2012). When to begin offering such clinics, in terms of age or life stage, is particularly important in these circumstances, alongside how often routine check-ups of this nature should occur

(Fortney 2012). Importantly, these screenings enable early detection of any issues, effectively providing benefits to the health of patients, and are consequently recommended to improve pet care and prevent common issues (Diez et al. 2015).

1.3 Defining old

In humans, old age can be associated with a change in the state of health and healthcare needs, and it is therefore important to define this life stage in order to focus on health interventions, as well as considering social aspects such as retirement (GOV-UK 2017; Urfer et al. 2020; WHO 2018). Defining elderly in humans for example is often based on age e.g. 65 years old (Sabharwal et al. 2015). Although humans and dogs often share environments with likely similar principles of ageing, dogs' lifespans are much shorter than humans, such that they may need more frequent health checks due to the quicker progression of chronic conditions, which may therefore require intervention accordingly (Fortney 2012; Kaymaz 2018). As such, human-pet analogy charts have been developed which define life stage based on chronological age and body weight in order to demonstrate the differences in time compression between humans and animals so that a relative comparison can be made (Fortney 2012).

Although the importance of old age is well recognised, there is no agreed consensus of when a dog is considered to have reached old age, and estimates can vary depending on a number of factors, for example breed or bodyweight (Willems et al. 2017). This may be due to the fact that words used to describe an animal in this life stage such as elderly, geriatric, or senior were intended as company marketing phrases (Davies 2016). The lack of a standard definition may also make it difficult to compare findings which may indicate what is considered as normal ageing for dogs progressing through life stages, as different studies may have used alternate age brackets to group dogs within (Harvey 2021; Szabó, Gee & Miklósi 2016)). Four life-stages have been suggested, namely: puppy,

adult, senior, and geriatric (Creevy et al. 2019; Fortney 2012). The age at which a dog is considered to enter the 'senior' life stage varies, highlighting the importance of ensuring discussions between an owner and veterinarian are appropriately timed. In doing so, medical intervention can be tailored to an individual and reduce the impact on their future health. With that being said, although the point at which an animal becomes senior is ambiguous, the definition acknowledges that an animal which has progressed to this senior life stage is still relatively healthy, and within the last 25% of their expected median lifespan (which may vary according to breed and body weight) (Creevy et al. 2019). In comparison to senior, a geriatric animal begins to experience age-associated issues and is therefore no longer considered healthy (Creevy et al. 2019; Fortney 2012). This definition of geriatric can be referred to in association with an animals' health span; that is, the length of time in which a dog is healthy and free of any illness (Wallis et al. 2018). In other words, geriatric is a state of health, compared to 'senior' which is a distinct and age-related category regardless of health.

Due to variation in defining the point at which dogs enter different life stages, there is discussion around the need for chronological categories to ensure appropriate discussion regarding old age animals and allow for monitoring of the normal ageing process, and detection of pathological ageing (Harvey 2021). This also needs to allow for different breeds as large sized breeds age faster than small sized breeds, and consequently die younger (Fan et al. 2016; Harvey 2021; Kraus, Pavard & Promislow 2013; Urfer et al. 2020). The influence of breed and size is taken into account in some approaches to defining old age. For example, one study suggests that larger dogs (≥22.7kg) are considered to be senior at 6-8y, and geriatric at 9y (Bellows et al. 2015b), but another suggests that larger dogs (>54kg) are senior at 4-5y, and geriatric at 6y old (Fortney 2012). For smaller dogs, the former study suggests smaller dogs (<22.7kg) are considered to be senior at 7-10y, and geriatric at 11y (Bellows et al. 2015b), and the latter study suggests smaller dogs (<9kg) are considered senior from 8-10y, and geriatric at 11y (Fortney 2012). However some raise concerns that this narrative

may allow for breed-specific welfare issues to go undetected, and that large breed dogs are not ageing faster but are instead dying younger due to inherited diseases; therefore, a chronological age category system should be implemented to avoid accepting early mortality in large breeds (Harvey 2021).

In comparison to dogs, four life stages have been defined for cats by the American Association of Feline Practitioners: kitten (up to one year old), young adult (1-6y), mature adult (7-10y), and senior (>10y) (Quimby et al. 2021). This may then be followed by an end of life stage which varies between individuals and can occur at any age, not necessarily simply following the senior life stages. Similar to dogs, life stages for cats' guide healthcare needs, and outline discussion topics and actions which should be addressed during a visit to practice within each stage. The recommended frequency of such visits is also defined per each life stage (Quimby et al. 2021). These four life stages were revised from a previous six-stage guideline, in the interests of facilitating easier conversations in practice with owners. Ultimately, these guidelines aim to ensure effective healthcare by addressing a range of needs to maintain a cat's welfare according to their life stage and throughout their life (Quimby et al. 2021).

1.4 Common issues of old age

Understanding what is part of normal healthy ageing and distinguishing this from unhealthy changes would enable effective management of healthcare for old age dogs (Bellows et al. 2015a). Using data from 784 UK-based clinics in 2016, common issues identified in dogs (aged 1.86-8.05y) were: dental disorder (14.1%), skin disorder (12.58%), enteropathy (10.43%), musculoskeletal (8.64%), ear disorder (8.17%), and obesity (7.07%) (O'Neill et al. 2021). This study analysed the frequency of common issues of dogs which presented to practice within one year and investigated the effects of age, sex, and neuter status. For example, dogs aged under 6y were diagnosed with infections and

allergy disorders, whilst dogs aged over 9y were diagnosed largely with degenerative disorders such as osteoarthritis. Female dogs were at increased odds for urinary system disorders, and neutered animals were at increased odds for dental disorders. However, the latter was confounded by age, as the median age of periodontal disease was 7.54y, meaning these older animals had more time to be neutered as neuter status can vary according to age (O'Neill et al. 2021). A novel approach using developed welfare metrics (VetCompass Welfare Impact score (VWI)) additionally indicated that common breed-related issues should be prioritised to maintain welfare, including: dental disorder (2.47 VWI), osteoarthritis (2.24 VWI), and overweight/obese (1.67 VWI), (Summers et al. 2019).

1.4.1 Obesity

Obesity is a common issue in old-age dogs, with a previous study reporting 59% of dogs in the UK were either overweight or obese, regardless of age (Courcier et al. 2010). This is an issue of concern as it may lead to other common issues in old age dogs such as osteoarthritis (Kealy et al. 2002), and may shorten life span (Kealy et al. 2002; Lund et al. 2006). Healthcare advice for obesity may include reducing energy intake and increasing activity, perhaps using a diet specifically for the purpose of weight loss which maintains satiety (German 2016). However, weight loss management can be challenging, and so it is important to maintain a healthy weight throughout a dog's life in order to prevent this issue from occurring (Brooks et al. 2013; German 2016).

1.4.2 Osteoarthritis

Osteoarthritis is a degenerative joint disease in which there is a loss and dysfunction of cartilage, which causes pain (Brandt, 2003). Prevalence in the UK can be between 2.5-6.6% in dogs of any age (O'Neill et al., 2014; Anderson, 2018). A diagnosis of osteoarthritis most frequently occurs in dogs aged 8y old or over, and dogs over 12y old had the highest odds of diagnosis (Anderson et al. 2018). However, whilst this may suggest that osteoarthritis is more common in older dogs and associated

with increasing age, this issue may go undetected and only be investigated at a later point in a dog's life when the condition has deteriorated (Anderson et al. 2018). Previous studies have found that a diagnosis can take time due to barriers, such as alternative approaches of diagnostic pathways used by practitioners, and owners which may not be aware of what may or may not be considered normal to bring to a veterinarian's attention, such as subtle behavioural signs (Belshaw et al., 2020). Alternative approaches to diagnosis include the use of a screening checklist to identify 188 cases in 500 dogs which would have been previously diagnosed, such methods may be ideal to utilise in efforts to improve diagnosis (Wright et al., 2022). In order to currently maintain optimal health and welfare, maintaining a healthy weight may help to prevent or reduce the impact of osteoarthritis; however, other treatments may also be needed including analgesics, which in a previous UK-based study, were used in 75.7% of cases (Anderson et al. 2018), as well as surgery, exercise restriction, and weight loss recommendation (Anderson et al. 2018; Johnson, Lee & Swanson 2020).

1.4.3 Cognitive dysfunction syndrome

Another issue in old age dogs is cognitive dysfunction syndrome (CDS), a neurodegenerative issue which can be compared to Alzheimer's syndrome in humans (Landsberg 2006; Studzinski et al. 2006). Previous studies have reported a prevalence of 14.2% using provisional diagnosis based on 27 behavioural signs in dogs aged over eight years (Landsberg 2006; Salvin et al. 2010; Studzinski et al. 2006). Another study reported signs of CDS in 28% of 11-12 year old dogs, and 68% of 15-16 year old dogs (Neilson et al. 2001). This is an important issue to consider with regards to ageing dogs, as it may help to indicate when pathological ageing is occurring, as evidence suggests there is no difference in neurological ageing between small and large breeds even though large breeds seem to die younger (Harvey 2021; Watowich et al. 2020; Salvin et al., 2012). CDS is another issue in which there seems to be underdiagnosis, and a need for awareness of signs to look out for this common health issue in old age dogs. There is a lack of research assessing the behavioural and cognitive

changes that may occur in an ageing dog (Chapagain et al., 2020). It is typically diagnosed by screening of behavioural signs by a veterinarian, and excluding other medical issues (Landsberg, 2006). Whilst prevalence has been reported at 14.2%, only 1.9% were diagnosed by a veterinarian (Salvin et al., 2010). Signs generally associated with CDS include anxiety, vocalising, altered sleep cycles, and disorientation (Landsberg, Nichol & Araujo 2012). In addition, impaired sensory function which also causes changes in behaviour may occur alongside CDS or separately (Landsberg 2006). Loss of sensory function may increase the progression of CDS, or result in overestimation of the prevalence of CDS, as some of the behavioural signs in both disorders are similar and it is difficult to ascertain the relative contribution to accelerated brain ageing and cognitive dysfunction (Landsberg 2006; Szabó, Gee & Miklósi 2016). These signs should be highlighted in order to understand what is normal or pathological (Szabó, Gee & Miklósi 2016). Treatments for CCD include therapeutic options such as environmental enrichment, diets and supplements, or medication to reduce the impact or slow down the progression of this issue (Landsberg 2006; Szabó, Gee & Miklósi 2016). However, recent work has emphasised the importance of using preventive measures against CDS rather than implementing treatment once cognitive decline has already begun (Prpar Mihevc & Majdič 2019).

1.4.4 Dental issues

Periodontal disease affects over 80% of dogs over three years of age (Enlund et al. 2020b). In terms of breed differences, small breeds are at greater risk of dental issues, especially as they get older (Harvey 1998; Stella, Bauer & Croney 2018). Smaller dogs have proportionally larger teeth (Gioso et al. 2001), and as a result of this experience tooth overcrowding and more plaque build-up (Kyllar, Doskarova & Paral 2013). The glycoprotein surface formed by saliva on the surface of teeth allows for bacteria to accumulate and form plaque, which over time increases and forms calculus which is facilitated by the alkaline pH of dog's saliva, which may ultimately lead to periodontal disease (Bringel et al. 2020; Stookey 2009). Daily tooth brushing may prevent plaque and calculus formation

by 37.4% and 80.2% respectively (Gawor et al. 2018). However, in the UK and Canada, owners do not seem to be aware of the importance of maintaining good oral hygiene for their pet (Lindinger 2016), perhaps due to the fact that owners find it difficult to check their dog's teeth and provide preventive dental care such as toothbrushing (Harvey, Serfilippi & Barnvos 2015), leading to concerns that dogs may have dental issues which are left untreated (Enlund et al. 2020b; Lindinger 2016). Diet may also influence the prevalence of dental issues, with soft diets being associated with a higher frequency and severity of periodontal disease (Gawor et al. 2006). In comparison, dry food diets aid plaque removal and can, therefore, provide oral health benefits (Stookey 2009). It is important to identify dental issues earlier rather than later to avoid periodontal disease from occurring by preventing any plaque build-up (Wallis & Holcombe 2020).

Treating dental issues may require general anaesthesia (Niemiec et al. 2020) which for older dogs, is often associated with increased risks of complication (Hughes 2008), highlighting the importance of identifying these issues early on. As such, it is important to carry out a pre-general anaesthetic check which may consist of blood tests, to ensure an animal is fit to undergo the procedure (Warne et al. 2018). It is also debated whether age alone is the risk factor with regards to general anaesthetic risk, rather that throughout their life, older dogs are more likely than younger dogs to have developed health issues which add to the risks associated with general anaesthesia (DeLay 2016). A study into anaesthesia related deaths for companion animals found that the risk has decreased in the last 20 years in the UK, although greater perioperative care should be taken for sick animals due to their higher risk of anaesthetic related death compared to healthy animals (Brodbelt et al., 2008). In addition, in a UK case-control study using primary care electronic patients records, older animals were also found to have increased risk of anaesthetic related death. In summary, it is important that owners are aware of this when making their decisions (Shoop-Worrall et al., 2022). Veterinarians are

required to inform owners of these risks, which may influence an owner's decision to decline the treatment option (Warne et al. 2018).

Ultimately, it would be beneficial to ensure owners proactively provide dental care for their dogs throughout their lives to avoid the predicament surrounding treatment options for dental issues in later life stages. These issues have led to the development of oral care products for pets, including chew toys, tooth brushes, soft rawhide, and products containing algae to improve oral health such as PlaqueOff (Gawor et al. 2018; Lindinger 2016; Stookey 2009). For example, dogs that consumed the antimicrobial plant-derived enzymes show a 37% reduced rate of plaque and also displayed no calculus formation (Lindinger 2016). Similarly, dogs fed a soft rawhide chew daily experienced a 28% reduction in calculus formation and 19% reduction in plaque formation (Stookey 2009). Other areas of research, which may indicate potential options for preventing the formation of calculus, involve identifying salivary proteins as biomarkers of periodontitis (Bringel et al. 2020).

1.4.5 Breed and size differences in health conditions

With increasing age, the risk of developing many chronic diseases increases. These risks vary amongst breeds, and these differences might explain breed lifespan differences (Jin et al. 2016). Thus, when comparing common old-age issues between breeds, some have recommended that having life-stage categories should highlight pathological ageing within breeds (Harvey 2021). For example, larger breeds were found to have an increased risk of being diagnosed with osteoarthritis in comparison to smaller breeds (Anderson et al. 2018), but smaller breeds were found to have a higher prevalence of periodontal disease (Wallis & Holcombe 2020). Given the differing health needs of dogs at different ages and breeds, rather than relying on age categories as a way of measuring life expectancy, some have advocated for the use of a frailty index (Harvey 2021). Such an index could account for biological ageing with regards to both physical and cognitive health and therefore more

accurately represents health status than an age category alone (Goggins et al. 2005; Hua et al. 2016; Mitnitski, Mogilner & Rockwood 2001). It also allows for prediction of mortality based on how frail a dog may be (Banzato et al. 2019).

1.4.6 Current recommendations for old age dogs

Overall, based on common issues observed in dogs of all ages, veterinarians have been reported to make between 0 and 7 recommendations within a health check, including vaccination (18% of 2957 recommendations), diet change (17%), deworming (17%), internal medicine examination (11%), dental care (10%), and weight loss management (7%) (Diez et al. 2015). Depending on the circumstances of a particular patient and the issues they may be experiencing, current guidelines in order to improve patient care, as per the American Animal Hospital Association, include various drugs, and nonpharmacological approaches such as exercise and physiotherapy, and adjusting the environment, ultimately aiming to enhance the quality of life of animals (Epstein et al. 2015). These may be guidelines to consider in the care for old age dogs.

1.4.7 Sex differences

In humans, women live longer than men (Ginter & Simko 2013). Evidence suggests that there may also be differences in ageing due to sex and/or neuter status in dogs. In the companion dog population, these differences are evident and likely due to intrinsic processes (Hoffman et al. 2018). For example, in a study of 3000 dogs, neutered females, entire males, and neutered males lived longer, when compared to entire females (O'Neill et al. 2013). Further, neutered females live significantly longer than male dogs (neutered and sexually-intact) and sexually-intact females (Michell 1999). Interestingly, in another study, in contrast to female dogs, sexually-intact male dogs live longer (Hoffman et al. 2018). That said, sex may only have a small effect on ageing and longevity (Hoffman et al. 2018).

1.5 Environmental differences

The effect of environmental conditions on the prevalence and severity of age-related diseases should also be considered. Highlighting these factors to owners could help to mitigate the impacts of old age associated issues. For example, environmental risk factors of obesity include diet and exercise, specifically causing a positive energy balance resulting in increased adipose tissue (Courcier et al. 2010). This may occur in older dogs due to their reduced metabolism, and so their energy intake should be adjusted accordingly to avoid weight gain (Taylor, Adams & Neville 1995). Although obesity is a multifaceted issue, making owners aware of the importance of adequate exercise and an appropriate diet may help to maintain a healthy weight for their pet dog throughout their life (Brooks et al. 2013; Courcier et al. 2010; German 2016).

In addition, there are potential environmental effects on the occurrence of canine cognitive dysfunction in the pet dog population. The risk of canine cognitive dysfunction may be decreased by providing a high-quality commercial diet rather than providing low quality commercial food, kitchen waste, or unspecified feed mixture (Katina et al. 2016). Alternatively, if signs of canine cognitive dysfunction are already apparent, nutritional supplements in the form of medium chain triglyceride may improve the condition (Pan et al. 2018). Understanding the effect of these environmental factors may help owners to adapt to suit their pets' needs in order to maintain their health and quality of life. This may be facilitated by conversations with their veterinarian.

1.6 Owners' perceptions

Common issues noticed by owners of older dogs include their dog sleeping more, a loss of hearing and vision, increased stiffness, thirst and urination, and dental disease. However, they may not be aware of or recognise the importance of these signs (Davies 2012). For example, in a prospective health screen study of dogs over nine years of age, which entailed a physical examination as well as

history records including the dog's lifestyle, in 80% of dogs there was at least one issue recorded that had been unnoticed by an owner who felt their dog was healthy (Davies 2012). This suggests that ongoing health issues might be missed in ageing dogs (Diez et al. 2015), but these issues may be detected by veterinarians during preventive screening programmes (Robinson et al. 2016). By detecting these issues, potential risk factors were identified allowing for appropriate modifications to be made and healthcare interventions applied to maintain quality of life (Davies 2012). This emphasises the need for veterinarians to have discussions with owners and raise their awareness of signs to be looking out for as their dog ages, and reinforces the need for regular check-ups of old age dogs to ensure any pathological signs are detected to allow for timely medical intervention.

Owners generally strive to provide the best for their dog (Westgarth et al. 2019b). However, although preventive healthcare is encouraged based on the potential benefits, the use of such methods is declining (Belshaw et al. 2018b; PDSA 2017). Owners may require communication from a veterinarian to support their knowledge on the need for preventive medicine to increase the implementation of preventive methods to maintain pet health (Belshaw et al. 2018b). Studies have also reported that pets who receive veterinary care (such as being seen by a veterinarian within the last year) received little preventive care (vaccination, flea and worm treatment, body condition scoring, and quality of diet and health status) (Diez et al. 2015). Evidence suggests that owners do not recognise signs of ill health in their pet dogs, may not provide adequate preventive healthcare, and differ in their perceptions of what is best for their dog. Therefore, there is a need to facilitate conversations between veterinarians and owners to improve the quality of life of the pet dog population. As a pet cannot directly communicate their experiences and feelings regarding their quality of life, this should be assessed using a standardised approach. Further, owners' perceptions are subjective and tools to facilitate and standardise measurement may help address this (Belshaw et al. 2015; Mwacalimba et al. 2020).

1.7 Implication for human - animal interaction

Companion animals have become an integral part of our lives and their welfare impacts the human-animal relationship. The human-animal bond has developed significantly, which has included the treatment of our companion animals as a part of the family (Charles & Davies 2008), together with observed parallels between parenting styles of children and dogs (German 2015; Herwijnen et al. 2018). There is a plethora of evidence supporting some benefits of dog ownership, for both owners and dogs, such as improved mental health experienced from a sense of companionship and facilitating social interactions, particularly for elderly owners (Overgaauw et al. 2020; Powell et al. 2019). Other benefits include decreased feelings of stress, and increased physical activity which provides its own range of positive impacts (Powell et al. 2019; Westgarth et al. 2019a). However, as dogs age and their needs change, it is important to increase owner awareness of the associated changes so that they can help to maintain their dog's quality of life (O'Neill et al. 2021). The relationship dynamic may also change in other ways; not only may caregiving burden increase (Spitznagel et al. 2017) and the costs of healthcare be a concern (Bellows et al. 2015a), but activities that may have typically occurred whilst the dog was younger and healthier may reduce or halt, such as off-lead walking, (Bellows et al. 2015a; Wallis et al. 2018), potentially impacting the positive impacts of dog ownership on owner physical activity (Westgarth et al. 2017). It is important to acknowledge these difficulties of caring for ageing animals, to either prevent a breakdown in the relationship between an old age dog and its owner, or conversely owners experiencing the relationship intensifying due to the increased demands of symptom management, and also not wanting to euthanise their pets (Britton et al. 2018; Wallis et al. 2018). This situation may prolong an animal's suffering, and cause emotional distress for the owner when required to make decisions regarding end-of-life care and euthanasia (Knesl et al. 2017). The impacts of this emotional distress have been reported to cause mental health issues such as depression and anxiety for owners, highlighting the need to address how these situations are approached to reduce such impacts

(Spitznagel et al. 2017). Ultimately, by meeting the needs of dogs and becoming more aware of the effects of ageing, we can improve human-animal interactions (Szabó, Gee & Miklósi 2016).

1.8 Use of electronic health records

In order to develop systems for the detection of health and welfare issues in old age dogs, it is key to first understand what exactly the issues prevailing within the ageing dog population are. Once these issues are identified, the current recommendations around prevention and treatment options should be evaluated in light of risk factors. This information including data on an animal's age, breed, weight, sex and neuter status is available within electronic health records (EHRs) collected in consultations and is, therefore, a viable route to pursue (Urfer et al. 2020). This data can be text-mined to extract relevant information, and the use of such data is increasing; however, it should be noted that the accuracy of such data in terms of reflection of true events within the consultation may vary (Jones-Diette et al. 2017). For example, similar issues are encountered when using such methods that utilise human healthcare records, as not all of what is discussed during a consultation is necessarily recorded within an electronic health record (Beasley et al. 2004; Jones-Diette et al. 2017). One study entailed observing the information recorded within the EHR by the attending veterinarian in a consultation and comparing this with the data which was collected in real time by a veterinary researcher who observed the consultation (Jones-Diette et al. 2017). This comparison found that only two thirds of issues discussed in a consultation were actually recorded, meaning a third of potential issues discussed are not captured and cannot, therefore, be included within analysis, thus reducing the validity of the data (Jones-Diette et al. 2017). However, the use of EHRs has been beneficial in monitoring infectious diseases and identifying high risk factor populations in order to improve population health (Paul et al. 2015). For example, EHRs have been used to identify disorder prevalence estimates (O'Neill et al., 2021), as well as prevalence of breed-related issues which highlights priority healthcare to improve welfare (Summers et al., 2019). Additional benefits

gained from EHRs include producing life table estimates for dog breeds, which again allows for a greater understanding of health throughout a dog's lifespan to maintain welfare (Teng et al., 2022). They can also be used to manage and improve the quality of care for patients, including those suffering with chronic diseases (Paul et al. 2015). Despite the aforementioned limitations, the use of EHRs provides potential benefits in the interests of One Health as an efficient and viable option for data collection and subsequent analysis to model disease in real-world applications (Lustgarten et al. 2020).

1.9 Aims

The aims of the study are to identify common health issues in old age dogs presented to veterinary surgeons, and investigate preventive healthcare and treatment recommendations recorded in the EHR, to determine whether there are any gaps which could be addressed through tailored healthcare messaging for owners of old age dogs.

1.10 Research questions

This project aims to address a number of research questions relating to health and ageing in dogs by taking a novel approach based on the ready growing availability of large volumes of EHRs:

- To determine when veterinary professionals consider a dog to have reached old age
    - To investigate whether veterinary professionals use of age-related words is associated with dog demographic factors
- To identify common issues in old age dogs when presenting to practice
    - To determine the onset of common issues in the vet-visiting dogs
    - To determine differences in occurrence and onset of common issues between dog demographic factors (including age, breed, and sex and neuter status)

- To investigate preventive healthcare and treatment recommendations of the most common issue sub-category (which for this study was dental issues of tartar, plaque, and calculus)
    - To investigate the demographics and epidemiology of dental tartar, plaque, and calculus in dogs presented to veterinary practice
    - To investigate what preventive healthcare advice is given
    - To investigate what range of treatment options are offered to owners

In Chapter two, when veterinarians perceived dogs as having reached old age was investigated and finds the age at which a dog may be defined as old age which may vary according to breed. In Chapter three, analysis explores the common issues of dogs which were identified as having reached old age, with findings of dental, digestive, integumentary, musculoskeletal and weight as the most common issues. And finally, in Chapter four, the most common issue was investigated in depth, specifically tartar issues within the dental category, finding that neutered dogs and specific breeds are at increased risk. Ultimately these findings can facilitate targeted health messaging for the old age dog population.

Chapter Two: Identifying old age dogs

2.1 Introduction

With old age comes an increased risk of age-associated issues. This is of particular concern due to the growing ageing dog population (Neilson et al. 2001) and, therefore, it is essential to understand these issues in order to ensure that, despite old age, our companion animals maintain their health for as long as possible, that the effects on welfare are minimised and they have a good quality of life. This entails understanding when different dog types experience old age, and which dog types are more at risk of age associated issues. In doing so, health messaging can become more targeted and tailored (personalised) depending on the individual. However, there is no agreed definition of when a dog reaches old age (Willems et al. 2017). This perhaps makes it difficult to conduct research and compare between studies which identify common issues in old age dogs or investigate the onset of old age depending on dog type (based on sex, neuter status, and breed). As such, alternative approaches to defining old age in dogs are useful, and one option is to base this on the opinion of veterinarians. This negates the complication of using a blanket definition of old age at age seven (Fortney 2012), as some animals may exhibit signs of old age prior to this point (Metzger 2005). It is also preferable to other approaches such as using weight (Bellows et al. 2015b; Fortney 2012), which may not allow for dogs who are underweight or overweight.

This study aimed to identify consultations in electronic health records (EHRs) where a veterinarian described, and therefore determined, a dog as having reached old age. After identifying such old-age dogs, the study also aimed to investigate how the description of old-age dogs (OADs) varied by dog type (breed, and sex and neuter status). Such an approach could facilitate future studies aiming to identify common issues and discussions around healthcare and treatment for OADs recorded in EHRs.

2.2 Methods

2.2.1 Ethical approval

Ethical approval for this project was obtained through the University of Liverpool Veterinary Ethics Committee (reference number 000964), verifying that the project did not breach the Animals Scientific Procedures Act 1986, and ensuring that client confidentiality is maintained with an option for owners to opt out. The Small Animal Veterinary Surveillance Network (SAVSNET) health record collection and analysis require ongoing ethical approval; however, a data access and publications application was submitted in order to obtain permission for the use of the data within this project.

2.2.2 SAVSNET

SAVSNET collects electronic health data in order to complete research and facilitate disease surveillance, the outcomes of which can be used to support small animal health and increase awareness of health priorities, such as preventive care. The SAVSNET database contains health records from 9 million consultations from a network of over 500 participating UK based veterinary practices, collected since 2014 (SAVSNET 2020). A written record of a veterinary consultation is created within EHRs, with the option for owners to opt out rather than the default option which is to opt-in (SAVSNET 2020). These records are sent to SAVSNET in near-real-time at the end of a consultation when submitted by veterinary surgeons (SAVSNET 2020). As well as containing free text, there is also information on age at consultation, date of birth, sex, neuter status, and breed.

2.2.3 Regex development

As there is no agreed consensus for when a dog is considered to have reached old age, an alternative approach was taken here to identify these dogs based on veterinary clinical narratives. A bespoke piece of software called Datalab is used to obtain the data from within the SAVSET-registered

practices. Datalab is a secure database that deidentifies consultation narratives for confidentiality purposes and can be text mined using regular expressions in Python. The validated regular expressions (regex) were developed in an iterative fashion in order to extract relevant free form text from within clinical consultation notes containing key words when applied to canine consultations.

This project uses language adopted by a veterinary professional to describe a patient as a marker of a dog having reached old age. Five key search words associated with dogs in a life-stage beyond adult were focused on within the regular expressions: 'ageing', 'elderly', 'geriatric', 'old', and 'senior': note, the phrase 'old age' is used throughout this project to refer to a dog which may have been described with any one of these words. Each search word selected was identified as a relevant word to extract the appropriate consultation notes based on the language used in the literature (Fortney 2012; Willems et al. 2017), as well as by expert opinion including an informal discussion amongst experienced veterinarians and researchers. These regular expressions will from here on in be referred to collectively as OAD RE (old age dog regular expressions). Regular expressions were designed to exclude any common negations which would otherwise retrieve clinical consultation notes that were not relevant to the study. For example, a negative look forward such as (?<!owner) may be used to exclude consultations talking about an elderly owner rather than an elderly dog. Datalab also features a tool based on machine learning to suggest common appropriate related phrases or spelling variations which could be incorporated into regular expressions in order to minimise the risk of inadvertent exclusion of relevant EHRs; for example, the 'Or' regex function was used as follows: (senior|senoir|seniour) to include different spelling variations of the keyword senior. Appropriate commonly used phrases in relation to the five key words were also incorporated into the regular expressions to extract relevant consultation notes. Relevant consultations included where the five key words were used in the context of old age and which identified old age dogs and the issues discussed when they present to practice. This combination ensured a range of words used

to describe ageing dogs were incorporated in order to form a diverse sample of 'old age' dogs as well as their associated health issues and treatments. The regular expressions developed and used can be found in Table 2.1, followed by examples of text which indicated an accurate or inaccurate match (Table 2.2). Consultation identification was completed using the secure database of Datalab and Microsoft Excel encrypted documents with identifiers removed.

Table 2.1: Regular expressions (regex) used to extract consultations which contain the relative word in the appropriate context within the free text of EHRs. (?<!) Negative look behind – exclude if this word precedes. (?!) Negative look ahead – exclude if this word follows. /s indicates a space. | indicates or

Word	Regular Expression
Ageing	(?<!no\ssigns\sof\s)(?<!no\sevidence\sof\s)(?<![a-z])ag(e)?ing|age-related
Elderly	(?<!owner\swho\swas\s)(?<!o\s)(?<!owner\s)(?<!owner\sis\s)(?<!o\sis\s)(eldery|el derley|elderly)(?!\s?(o(w|\s|\,|\.|\- |\')|lady|gent|man|woman|couple|parents|neighbour|mother|mum|father|relat ive|client|friend|grandfather|grandmother))
Geriatric	(geriatric|geriatic|geratric|geriartic|geriactric)(?!\s?feline\s?panel)
Old	(?<!week\s)(?<!wk\s)(?<!weeks\s)(?<!ws\s)(?<!wks\s)(?<!mo\s)(?<!m\s)(?<!mth\s)(? <!mths\s)(?<!month\s)(?<!months\s)(?<!day\s)(?<!days\s)(?<!(\d)d\s)(?<!(\d)w\s)(? <!hrs\s)(?<![0-4]\sy\s)(?<![0-4]\syr\s)(?<![0-4]\syear\s)(?<![0-4]\syears\s)((?<![a-z])old|(?<![a-z])ols|(?<![a-z])older|old- age)(?!\s?(ulcer|healing|house|people|dirt|flea|corneal|scar|food|cruciate|melo xaid|injur|wound|scab|uncle|grandson|daughter|vet|practice|lesion|superficial| abscess|fracture|carrier|sample|cyst|break|passport|trauma|enough|dried discharge|damage|collar|rules|laceration|address|tick|history|healed|resolving|s tyle|child|machine|scratch|one|crust|hotspot|discharge|self|selves|staining|clot |diet|prices|baby|owner|keratitis|scheme|bandage|chip|bite|xrays|ccl injury|claw|surgical site|bumblefoot|umbilical|puncture|blood|seb|dried|coat|fight|adenoma|pyoder ma|patches|number|microchip|saliva|cut|dry|policy|wart|nail|issue|material|ca rpet|drip))
Senior	(?<!o\s)(?<!owner\s)(?<!owner\sis\s)(?<!o\sis\s)(senior|senoir|seniour|(?<![az])snr |seniro)(?!\s?(o(w|\s|,|\.|- |')|lady|gent|man|woman|mother|father|relative|neighbour|parent|couple|vet| nurse|surgeon|carer|member\sof\sstaff))

Table 2.2: Examples of text which indicated a match for each OAD RE (old age dog regular expression) in a sample of 832 consultations. Text is reproduced verbatim with occasional spelling mistakes.

OAD RE	Accurate Matches	Inaccurate Matches
Ageing	suspect an ageing change,	Exercising less as other dog ageing
	generally doing great for aging, slowing down v slightly	
	suspect age-related incontinence	Vomiting aging yesterday
Elderly	Overall for elderly dog doing really good.	communication difficult as owner deaf and elderly
	dog v. distressed and elderly	rehomed to rspca from family where elderly member died
	Also as elderly patient is higher risk	better to do now on a slightly fitter 9 y/o than on a a more elderly 12 y/o
	Dog elderly for his type. Likely to spend more time lying down	O does have another elderly dog who she has seen drinking more.
Geriatric	Geriatric dog	attacks - nto typically like idiopatic or geriatric vestibular ttacs -
	Bloods taken for geriatric screen	
	patient is geriatric.	
	as dog so geriatric and otherwise so well.	
Old	result of old age is my suspicion.	Has older dog at home
	owner wants to monitor as an old dog.	Owner restarted old meds
	is older and slow	Use an old sock
	Advised old age is causing the problems but we still need to do something about it	Some old discolorated wound
Senior	Suggested senior wellness profile, incase got underlying issues	Snr died in he summer so just mum
	Friendly dog. Healthy senior dog.	
	discussed pga bloods owner declined but will have drip as senior dog	Doesn't want to eat puppy food so is usigng senior; advised puppy is best but she does need some nutrition so sentior is better than nothing at all.
	advise more premium senior dog food	

For each identified 'old age' consultation, information was extracted into a new database. This included OAD RE (old age dog regular expression), species, age, sex, and neuter status. A random sample of 200 consultations (extracted using Datalab random functionality) were categorised for each OAD RE. The number of 200 consultations for each OAD RE was selected as the appropriate sample size due to time constraints for the researcher to read each EHR. The data were then cleaned, removing any consultations with missing data, due to a dog being >30y (dogs <30y included,

given that the world record of the oldest dog was 29y (Guinness, n.d.), or if a consultation was present more than once. Overall, data obtained included OAD RE, age, sex, neuter status, breed, and the consultation free text, and for the purpose of analysis, breeds with a sample size of 10 or less were combined into an 'other' category (170).

2.2.4 Statistical analysis methods

The approximate accuracy of each OAD RE in returning relevant consultations (dog-specific sample) was provisionally estimated by reviewing the first 100 consultation notes per OAD RE and assessing whether each case qualified in meeting the conditions of the case definition. Descriptive statistics were used to summarise the data. The association between the continuous outcome of age and categorical variables (old age word used by the vet, breed, sex, and neuter status), was determined using pairwise comparisons and the Kruskal-Wallis test, with post-hoc comparisons conducted using Dunn's tests. The association between categorical outcomes (old age word used) and variables (breed, sex, neuter status) was assessed using the Chi-squared test. The association between the top six most common breeds was compared through a binary logistic regression. Within the logistic regression, for breed the reference category was chosen based on the breed with the lowest odds ratio when univariable modelling was performed using Mixed Breed as an initial reference. Statistical significance was set at $P \leq 0.05$ and the analyses were conducted using the SPSS data software package (SPSS version 26.0, IBM Corp.).

2.3 Results

2.3.1 Regex accuracy

The approximate accuracy of each OAD RE based on reading 100 narratives was: 'ageing' (97%), 'elderly' (90%), 'geriatric' (99%), 'old' (52%), and 'senior' (99%) (Table 2.3).

2.3.2 Regex returns of the full OAD sample

The total number of matches in the entire SAVSNET database of canine consultations were: 'ageing' (1,890), 'elderly' (6,536), 'geriatric' (3,374), 'old' (34,226), and 'senior' (23,121). After removal of consultations with inaccuracies (such as date of birth recorded as the date of consultation) and incomplete fields, the number of dog specific results (49,428) were: 'ageing' (1,854, 3.75%), 'elderly' (2,903, 5.87%), 'geriatric' (3,279, 6.63%), 'old' (33,220, 67.21%), and 'senior' (8,172, 16.53%) (total = 49,428).

Based on the regex estimated accuracies, of the total of 49,428 consultations found by the OAD Res, 33,021 (66.8%) would be estimated to involve older animals. The predicted number of accurate EHRs in a 5x200 canine sample was estimated (Table 2.3); these estimated numbers were considered suitable and so the approach of reading 200 consultations found by each OAD RE was taken forward in the next part of the study (2.3.5).

Table 2.3: A summary of approximate final OAD RE accuracies (based on reading 100 consultations found by each regex) and the predicted number of accurate EHRs what would be obtained if the OAD REs were applied to 200 random Datalab consultations.

	Ageing	Elderly	Geriatric	Old	Senior
Number of consults found by each regex	1,854	2,903	3,279	33,220	8,172
Approximate accuracy based on reading 100 consultations (%)	97	90	99	52	99
Number of predicted correctly allocated old age consultations in the total dataset	1,798	2,613	3,246	17,274	8,090
Number of predicted correctly allocated consultations in 200	194	180	198	104	198

2.3.3 Demographics of the OAD sub-sample

From the sample of 200 random dog-specific consultations extracted for each of the five OAD REs (1000), 169 consultations were excluded; this included 157 consultations which did not accurately meet the case definition; 11 additional consultations which met the case definition but were missing breed data; and one which appeared to be a duplication. Three dogs were present twice as they matched two of the regular expressions (Animal ID; 350209 detected by 'Ageing' and 'Geriatric', 431543 detected by 'Ageing' and 'Elderly', 880746 detected by 'Geriatric' and 'Senior'); one consultation for each animal was randomly selected to be taken forward (Animal ID; 350209 selected for 'Ageing', 431543 selected for 'Ageing', 880746 selected for 'Geriatric'). This left a final dataset of 832 consultations (the OAD sub-sample) available for further analysis which included: 176 'ageing' (21.15%), 164 'elderly' (19.71%), 197 'geriatric' (23.68%), 105 'old' (12.62%), and 190 'senior' (22.84%) consultations. This sub-sample of 832 vet visiting OAD dogs was 51% female (427) and 49% male (405). Furthermore, the sample contained 40% neutered (329) females compared to 34% neutered (285) males. Eighty-six breeds were represented (median = 2, range 1-180 dogs of each breed). The most common breeds were Mixed Breed (180, 22%), Labrador Retriever (108, 13%), Jack Russell Terrier (60, 7%), Cocker Spaniel (48, 6%), Border Collie (47, 6%), and Springer Spaniel (36, 4%).

2.3.4 When veterinarians consider a dog to be of old age; full OAD sample

The median age of the full sample of dogs which were detected by the OAD regular expressions (49,428) was 11.2y. The median age for the use of each OAD RE was as follows: 'elderly' (13.6y), 'ageing' (12.4y), 'geriatric' (12.3y), 'senior' (11.0y), and 'old' (10.7y). There was evidence for a difference in age in the use of each OAD RE apart from between 'geriatric' and 'ageing' ($P<0.05$; Table 2.4).

Table 2.4: A) Descriptive statistical summary of the age of the five OAD REs in the full OAD sample (49,428) B) Pairwise comparisons of the median age of each OAD RE for the full sample of OAD (49,428), independent samples Kruskal Wallis test

Table 2.4 A

Word	Median Age (Years)	Range	IQR
Ageing (1,854)	12.38	0.17-18.91	10.56-13.84
Elderly (2,903)	13.57	0-21.23	11.68-14.97
Geriatric (3,279)	12.28	0-19.59	10.46-13.81
Old (33,220)	10.68	0-19.23	5.51-13.26
Senior (8,172)	10.96	0.23-20.44	9.14-12.75

Table 2.4 B

Words Compared	*P* Value Pairwise	*P* Value Total
Old vs Senior	**0.000**	0.000
Old vs Geriatric	**0.000**	
Old vs Ageing	**0.000**	
Old vs Elderly	**0.000**	
Senior vs Geriatric	**0.000**	
Senior vs Ageing	**0.000**	
Senior vs Elderly	**0.000**	
Geriatric vs Ageing	0.613	
Geriatric vs Elderly	**0.000**	
Ageing vs Elderly	**0.000**	

2.3.5 When veterinarians consider a dog to be of old age; sub-sample of OAD

The median age of the sub-sample of dogs (832) was 12.5y, (range 0-20.5y, IQR=10.4-14.2; negative-skew, Figure 2.1). Five percent of the 832 dogs were aged under 7y, including some that were very young (e.g. recorded elderly at 0y); these small number are likely to reflect rare inaccuracies in the age field of the EHR. Use of each OAD RE peaked between 10-15y of age (Figure 2.2). The median age for the use of each OAD RE was as follows: 'elderly' (14.0y), 'ageing' (12.5y), 'geriatric' (11.8y), 'senior' (10.7y), and 'old' (12.9y). There was evidence for a difference in age in the use of OAD REs as follows; 'senior' vs geriatric', 'senior' vs 'ageing', 'senior' vs 'old', 'senior' vs 'elderly', 'geriatric' vs 'old', 'geriatric' vs 'elderly', 'ageing' vs elderly', and 'old' vs 'elderly (P<0.05; Table 2.5).

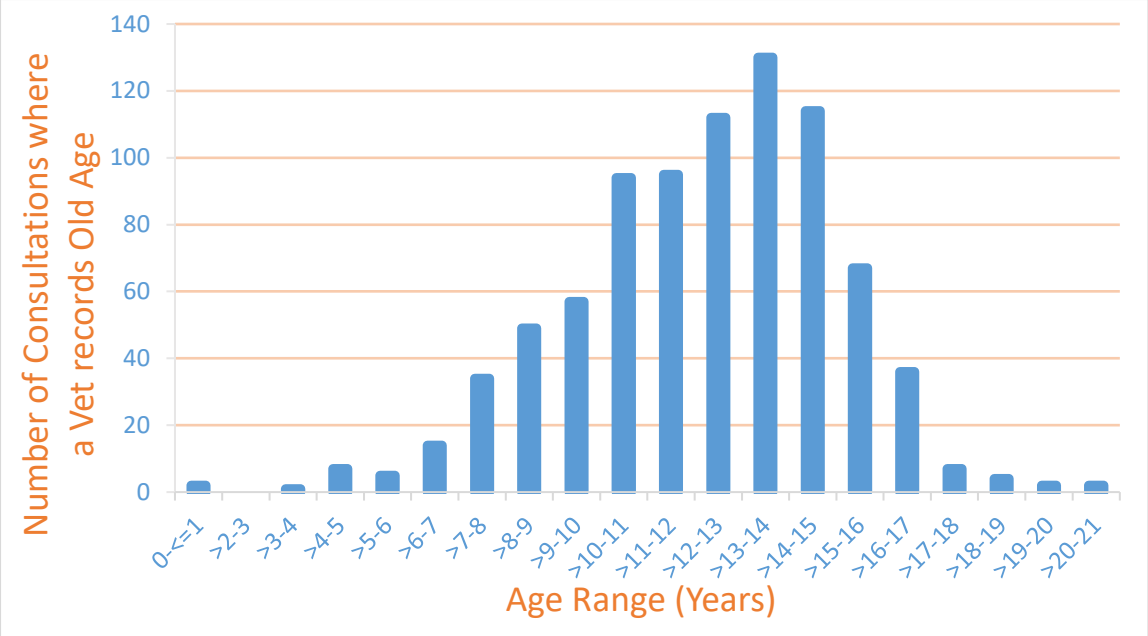

Figure 2.1: Age distribution of dogs described as having reached old age by a veterinarian in the OAD sub-sample (832)

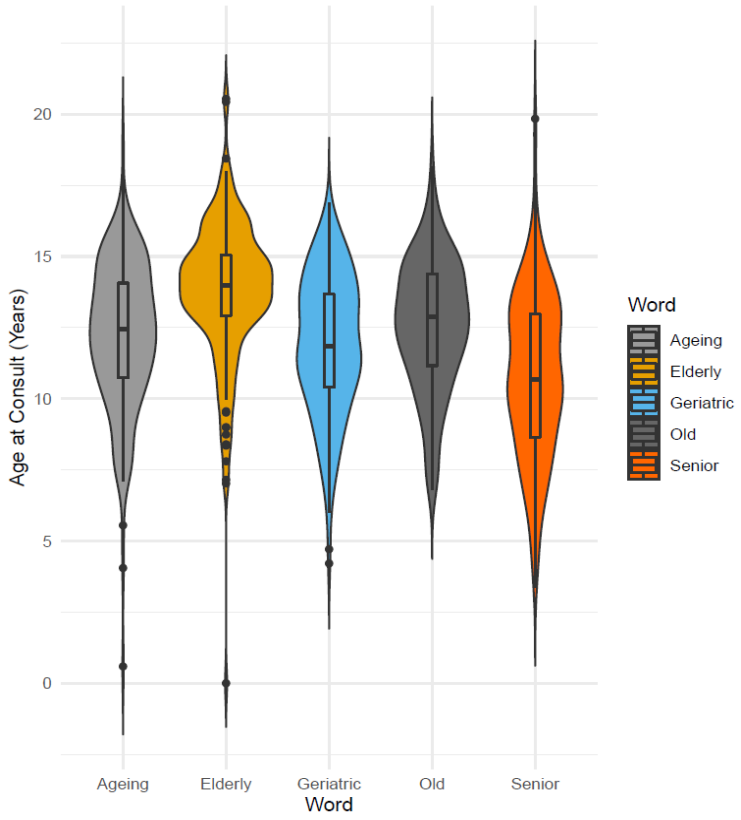

Figure 2.2: Violin plot demonstrating the age distribution for each of the five OAD RE used by veterinarians to describe a dog as having reached old age in the OAD sub-sample (832).

Table 2.5: A) Descriptive statistical summary of the age of dogs identified by the five OAD REs in the OAD sub-sample (832) B) Pairwise comparisons of the median age of dogs identified by the five OAD REs in the OAD sub-sample (832), independent samples Kruskal Wallis test

Table 2.5 A

OAD RE	Median Age (Years)	Range	IQR
Ageing (176)	12.31	0.59-18.91	10.55-14.08
Elderly (164)	13.89	0-20.54	12.64-15.14
Geriatric (197)	11.82	4.21-16.88	10.39-13.63
Old (105)	12.87	6.81-18.15	11.14-14.42
Senior (190)	10.70	3.36-19.84	8.60-13.02

Table 2.5 B

Words Compared	*P* Value Pairwise	*P* Value Total
Senior vs Geriatric	**0.000**	0.000
Senior vs Ageing	**0.000**	
Senior vs Old	**0.000**	
Senior vs Elderly	**0.000**	
Geriatric vs Ageing	0.187	
Geriatric vs Old	**0.042**	
Geriatric vs Elderly	**0.000**	
Ageing vs Old	0.379	
Ageing vs Elderly	**0.000**	
Old vs Elderly	**0.000**	

2.3.6 Age, sex, and neuter status; full OAD sample

The median age of the full OAD sample differed significantly by sex and neuter status; sexually intact females (9.36y), neutered females (11.72y), sexually intact males (10.43y), and neutered males (11.40y) (Table 2.6, *P*=0.000).

Table 2.6: A) Descriptive statistical summary of the age of dogs by sex and neuter status in the full OAD sample (49,428). B) Pairwise comparisons of the age of dogs by sex and neuter status in the full OAD sample (49,428), independent samples Kruskal Wallis test

Table 2.6 A

Sex/Neuter Status	Median Age (Years)
Sexually Intact Male (8,943)	10.43
Neutered Male (15,961)	11.40
Sexually Intact Female (6,901)	9.36
Neutered Female (7,623)	11.72

Table 2.6 B

Sex/Neuter Status Compared	*P* Value Pairwise	*P* Value Total
Sexually Intact Female vs Sexually Intact Male	**0.000**	0.000
Sexually Intact Female vs Neutered Male	**0.000**	
Sexually Intact Female vs Neutered Female	**0.000**	
Sexually Intact Male vs Neutered Male	**0.000**	
Sexually Intact Male vs Neutered Female	**0.000**	
Neutered Male vs Neutered Female	**0.000**	

2.3.7 Age, sex and neuter status; OAD sub-sample

In contrast to the larger data set, the median age of the OAD sub-sample did not significantly differ by sex and neuter status; sexually intact females (13.00y), neutered females (12.47y), sexually intact males (12.48y), and neutered males (12.49y) (*P*=0.285).

2.3.8 OAD RE by sex and neuter status; full OAD sample

The proportion of each sex and neuter status combined, as well as sex, and neuter status alone, differed between each OAD RE (Table 2.7, *P*=0.000;

P=0.000, *P*=0.000 respectively).

Table 2.7: Chi-squared analysis of sex and neuter status combined, sex, and neuter status by the five OAD REs in the full OAD sample (49,428)

Outcome	Variable										
	Sexually Intact Male (8,943)	Male Neutered (15,961)	Sexually Intact Female (6,901)	Female Neutered (17,623)	*P*	Male (24,904)	Female (24,524)	*P*	Sexually Intact (15,844)	Neutered (33,584)	*P*
Ageing (1,854)	266 (14.3)	683 (36.8)	146 (7.9)	759 (40.9)	0.000	949 (51.2)	905 (48.8)	0.000	412 (22.2)	1,442 (77.8)	0.000
Elderly (2,903)	463 (15.9)	928 (32.0)	402 (13.8)	1,110 (38.2)		1,391 (47.9)	1,512 (52.1)		865 (29.8)	2,038 (70.2)	
Geriatric (3,279)	463 (14.1)	1,098 (33.5)	322 (9.8)	1,396 (42.6)		1,561 (47.6)	1,718 (52.4)		785 (23.9)	2,494 (76.1)	
Old (33,220)	6,675 (20.1)	10,236 (30.8)	5,368 (16.2)	10,941 (32.9)		16,911 (50.9)	16,309 (49.1)		12,043 (36.3)	21,177 (63.7)	
Senior (8,172)	1,076 (13.2)	3,016 (36.9)	663 (8.1)	3,417 (41.8)		4,092 (50.1)	4,080 (49.9)		1,739 (21.3)	6,433 (78.7)	

There was no evidence for a difference in median age by sex within: 'ageing' (*P*=0.107), 'geriatric' (*P*=0.203), or 'senior' (*P*=0.226). There was evidence for a difference in median age by sex within 'elderly' (Table 2.8, *P*=0.021), and 'old' (Table 2.9, *P*=0.000).

Table 2.8: A) Descriptive statistical summary of the age of dogs by sex and neuter status in the full OAD sample for the 'elderly' OAD RE (2,903) B) Pairwise comparisons of the age of dogs by sex and neuter status in the full OAD sample for the 'elderly' OAD RE (2,903), independent samples Kruskal Wallis test

Table 2.8 A

Sex/Neuter Status	Median Age (Years)
Sexually Intact Male	13.57
Neutered Male	13.45
Sexually Intact Female	13.41
Neutered Female	13.71

Table 2.8 B

Sex/Neuter Status Compared	*P* Value Pairwise	*P* Value Total
Sexually Intact Female vs Sexually Intact Male	0.109	0.021
Sexually Intact Female vs Neutered Male	0.338	
Sexually Intact Female vs Neutered Female	**0.006**	
Neutered Male vs Sexually Intact Male	0.359	
Sexually Intact Male vs Neutered Female	0.357	
Neutered Male vs Neutered Female	**0.020**	

Table 2.9: A) Descriptive statistical summary of the age of dogs by sex and neuter status in the full OAD sample for the 'old' OAD RE (33,220) B) Pairwise comparisons of the age of dogs by sex and neuter status in the full OAD sample for the 'old' OAD RE (33,220), independent samples Kruskal Wallis test

Table 2.9 A

Sex/Neuter Status	Median Age (Years)
Sexually Intact Male	9.48
Neutered Male	11.11
Sexually Intact Female	7.60
Neutered Female	11.54

Table 2.9 B

Sex/Neuter Status Compared	*P* Value Pairwise	*P* Value Total
Sexually Intact Female vs Sexually Intact Male	**0.000**	0.000
Sexually Intact Female vs Neutered Male	**0.000**	
Sexually Intact Female vs Neutered Female	**0.000**	
Sexually Intact Male vs Neutered Male	**0.000**	
Sexually Intact Male vs Neutered Female	**0.000**	
Neutered Male vs Neutered Female	**0.000**	

2.3.9 OAD RE by sex and neuter status; OAD sub-sample

The proportion of each sex and neuter status combined, sex, and neuter status, did not differ between each OAD RE (Table 2.10, *P*=0.458; *P*=0.320, *P*=0.230 respectively).

Table 2.10: Chi-squared analysis of sex and neuter status combined, sex, and neuter status by the five OAD REs in the OAD sub-sample (832)

Outcome	Variable										
	Sexually Intact Male (120)	Male Neutered (285)	Sexually Intact Female (98)	Female Neutered (329)	*P*	Male (405)	Female (427)	*P*	Sexually Intact (218)	Neutered (614)	*P*
Ageing (176)	26 (14.8)	64 (36.4)	21 (11.9)	65 (36.9)		90 (51.1)	86 (48.9)		47 (26.7)	129 (73.3)	
Elderly (164)	28 (17.1)	57 (34.8)	22 (13.4)	57 (34.8)		85 (51.8)	79 (48.2)		50 (30.5)	114 (69.5)	
Geriatric (197)	34 (17.3)	65 (33.0)	20 (10.2)	78 (39.6)	0.458	99 (50.3)	98 (49.7)	0.320	54 (27.4)	143 (72.6)	0.230
Old (105)	13 (12.4)	29 (27.6)	16 (15.2)	47 (44.8)		42 (40.0)	63 (60.0)		29 (27.6)	76 (72.4)	
Senior (190)	19 (10.0)	70 (36.8)	19 (10.0)	82 (43.2)		89 (46.8)	101 (53.3)		38 (20.0)	152 (80.0)	

There was no evidence for a difference in median age by sex within: ‘ageing’ (*P*=0.138), ‘elderly’ (*P*=0.235), ‘geriatric’ (*P*=0.361), ‘old’ (*P*=0.942) or ‘senior’ (*P*=0.891).

2.3.10 Age and breed; full OAD sample

The median age of the six most common and "other breeds" in the full OAD sample (49,428) was 11.2y. The median age for each breed differed (Table 2.11, P<0.001): Mixed Breed (11.6y), Labrador Retriever (11.1y), Jack Russell Terrier (13.2y), Cocker Spaniel (10.9y), Border Collie (12.0y), Springer Spaniel (11.9y), and Other (10.7y).

Table 2.11: A) Descriptive statistical summary of the age of dogs by breed in the full sample of OAD (49,428) B) Pairwise comparisons of the median age of breeds in the full sample of OAD (49,428), independent samples Kruskal Wallis test

Table 2.11 A

Breed	Median Age (Years)	Range	IQR
Mixed Breed	11.61	0-22.5	8-13.98
Labrador Retriever	11.08	0-17.92	8.43-12.85
Jack Russell Terrier	13.16	0-20.67	10.43-15.00
Cocker Spaniel	10.85	0-20.0	7.25-13.00
Border Collie	12	0-18.73	9.14-13.81
Springer Spaniel	11.88	0-18.27	9.2-13.41
Other	10.67	0-20.44	6.75-13.06

Table 2.11 B

Breeds Compared	*P* Value Pairwise	*P* Value Total
Cocker Spaniel vs Other	0.827	0.000
Cocker Spaniel vs Labrador Retriever	**0.011**	
Cocker Spaniel vs Mixed Breed	**0.000**	
Cocker Spaniel vs Springer Spaniel	**0.000**	
Cocker Spaniel vs Border Collie	**0.000**	
Cocker Spaniel vs Jack Russell Terrier	**0.000**	
Other vs Labrador Retriever	**0.000**	
Other vs Mixed Breed	**0.000**	
Other vs Springer Spaniel	**0.000**	
Other vs Border Collie	**0.000**	
Other vs Jack Russell Terrier	**0.000**	
Labrador Retriever vs Mixed Breed	**0.000**	
Labrador Retriever vs Springer Spaniel	**0.000**	
Labrador Retriever vs Border Collie	**0.000**	
Labrador Retriever vs Jack Russell Terrier	**0.000**	
Mixed Breed vs Springer Spaniel	0.268	
Mixed Breed vs Border Collie	**0.005**	
Mixed Breed vs Jack Russell Terrier	**0.000**	
Springer Spaniel vs Border Collie	0.249	
Springer Spaniel vs Jack Russell Terrier	**0.000**	
Border Collie vs Jack Russell Terrier	**0.000**	

2.3.11 Age and breed; OAD sub-sample

The median age of the top six most common and "other breeds" in the subsample (832) was 12.5y. The median age for each breed was as follows: Mixed Breed (13.2y), Labrador Retriever (12.2y), Jack Russell Terrier (14.1y), Cocker Spaniel (11.7y), Border Collie (12.7y), Springer Spaniel (12.5y), and Other (12.3y). Figure 2.3 demonstrates median age for common breeds with more than 10 dogs. There was evidence of a difference in age between the Cocker Spaniel (11.7y) vs Jack Russell Terrier (14.1y, P=0.000), and the Labrador Retriever (12.2y) vs Jack Russell Terrier (P<0.001). The pairwise comparisons can be found in Table 2.12.

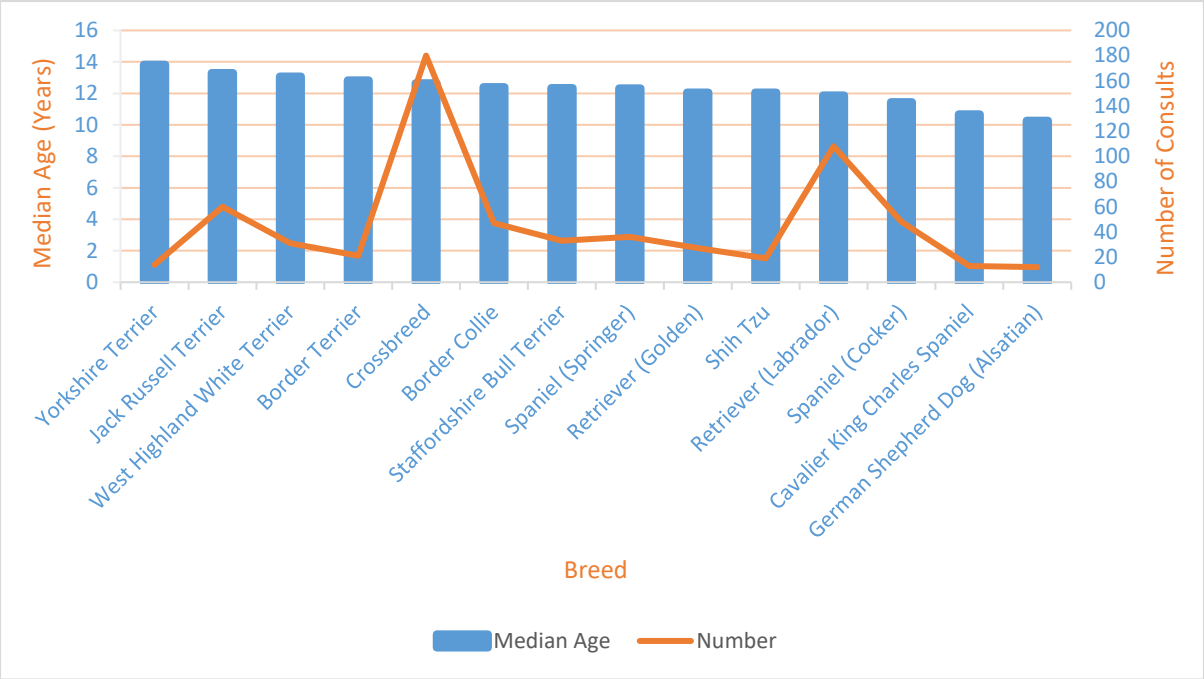

Figure 2.3: Median age and number of consultations of breeds with more than 10 dogs (649)

Table 2.12: A) Descriptive statistical summary of the age of dogs by breed in the OAD sub-sample (832) B) Pairwise comparisons of the age of dogs by breed in the OAD sub-sample, independent samples Kruskal Wallis test

Table 2.12 A

Breed	Median Age (Years)	Range	IQR
Mixed Breed	13.23	5.53-19.12	10.63-14.51
Labrador Retriever	12.12	3.36-16.24	10.47-13.57
Jack Russell Terrier	14.06	0-20.54	10.47-15.91
Cocker Spaniel	11.70	5.16-17.02	10.20-13.10
Border Collie	12.70	4.05-16.61	11.31-14.12
Springer Spaniel	12.53	7.43-17.73	10.93-13.80
Other	12.27	0.59-17.58	10.13-13.88

Table 2.12 B

Breeds Compared	*P* Value Comparison	*P* Value Total
Cocker Spaniel vs Labrador Retriever	0.437	0.000
Cocker Spaniel vs Other	0.184	
Cocker Spaniel vs Springer Spaniel	0.166	
Cocker Spaniel vs Border Collie	0.060	
Cocker Spaniel vs Mixed Breed	**0.004**	
Cocker Spaniel vs Jack Russell Terrier	**0.000**	
Labrador Retriever vs Other	0.526	
Labrador Retriever vs Springer Spaniel	0.376	
Labrador Retriever vs Border Collie	0.150	
Labrador Retriever vs Mixed Breed	**0.006**	
Labrador Retriever vs Jack Russell Terrier	**0.000**	
Other vs Springer Spaniel	0.565	
Other vs Border Collie	0.241	
Other vs Mixed Breed	**0.004**	
Other vs Jack Russell Terrier	**0.000**	
Springer Spaniel vs Border Collie	0.713	
Springer Spaniel vs Mixed Breed	0.362	
Springer Spaniel vs Jack Russell Terrier	0.053	
Border Collie vs Mixed Breed	0.603	
Border Collie vs Jack Russell Terrier	0.093	
Mixed Breed vs Jack Russell Terrier	0.105	

The age of the top six most common breeds was then compared within each OAD RE sample. For 'Ageing' (176), the median age was 12.5y. There was no evidence of a difference in age for each breed when described as 'ageing' (*P*=0.336). For 'Elderly' (164), the median age was 14.0y. The median age of each breed within 'Elderly' was as follows: Mixed Breed (14.35y), Labrador Retriever (13.59y), Jack Russell Terrier (16.08y), Cocker Spaniel (14.42y), Border Collie (11.72y), Springer Spaniel (13.79y), and Other (13.68y) (*P*=0.012). There was evidence of a difference in age for each breed when described as 'elderly' between Border Collie vs Jack Russell Terrier, Labrador Retriever vs Jack Russell Terrier, Mixed Breed vs Jack Russell Terrier, and Other vs Jack Russell Terrier. The pairwise comparisons can be found in table 2.13. For 'Geriatric' (197), the median age was 11.8y. There was no evidence of a difference in age for each breed when described as 'geriatric' (*P*=0.464). For 'Old' (105), the median age was 13.0y. The median age of each breed within 'Old' was as follows: Mixed Breed (13.4y), Labrador Retriever (12.3y), Jack Russell Terrier (15.1y), Cocker Spaniel (11.3y), Border Collie (12.8y), Springer Spaniel (13.1y), and Other (12.1y) (*P*=0.019). There was evidence of a difference in age for each breed when described as 'old' between Cocker Spaniel vs Jack Russell Terrier, Labrador Retriever vs Jack Russell Terrier, Border Collie vs Jack Russell Terrier, Mixed Breed vs Jack Russell Terrier, and Other vs Jack Russell Terrier. The pairwise comparisons can be found in Table 2.14. For 'Senior' (190), the median age was 10.7y. There was no evidence of a difference in age for each breed when described as 'senior' (*P*=0.080).

Table 2.13: Median a*ge pairwise comparison of breeds described with the 'elderly' OAD RE in the OAD sub-sample (164), independent samples Kruskal Wallis test*

Breed	Median Age (Years)
Mixed Breed	14.35
Labrador Retriever	13.59
Jack Russell Terrier	16.08
Cocker Spaniel	14.42
Border Collie	11.72
Springer Spaniel	13.79
Other	13.68

Breeds Compared	*P* Value Pairwise	*P* Value Total
Border Collie vs Labrador Retriever	0.772	**0.012**
Border Collie vs Other	0.447	
Border Collie vs Mixed Breed	0.330	
Border Collie vs Springer Spaniel	0.403	
Border Collie vs Cocker Spaniel	0.203	
Border Collie vs Jack Russell Terrier	**0.008**	
Labrador Retriever vs Other	0.478	
Labrador Retriever vs Mixed Breed	0.312	
Labrador Retriever vs Springer Spaniel	0.463	
Labrador Retriever vs Cocker Spaniel	0.210	
Labrador Retriever vs Jack Russell Terrier	**0.001**	
Other vs Mixed Breed	0.598	
Other vs Springer Spaniel	0.706	
Other vs Cocker Spaniel	0.333	
Other vs Jack Russell Terrier	**0.000**	
Mixed Breed vs Springer Spaniel	0.906	
Mixed Breed vs Cocker Spaniel	0.477	
Mixed Breed vs Jack Russell Terrier	**0.005**	
Springer Spaniel vs Cocker Spaniel	0.635	
Springer Spaniel vs Jack Russell Terrier	0.102	
Cocker Spaniel vs Jack Russell Terrier	0.338	

*Table 2.14: Median a*ge pairwise comparison of breeds described with the 'old' OAD RE in the OAD sub-sample (105), independent samples Kruskal Wallis test

Breed	Median Age (Years)
Mixed Breed	13.40
Labrador Retriever	12.30
Jack Russell Terrier	15.10
Cocker Spaniel	11.30
Border Collie	12.80
Springer Spaniel	13.10
Other	12.10

Breeds Compared	*P* Value Pairwise	*P* Value Total
Cocker Spaniel vs Other	0.184	0.019
Cocker Spaniel vs Labrador Retriever	0.194	
Cocker Spaniel vs Border Collie	0.176	
Cocker Spaniel vs Mixed Breed	0.038	
Cocker Spaniel vs Springer Spaniel	0.385	
Cocker Spaniel vs Jack Russell Terrier	**0.000**	
Other vs Labrador Retriever	0.907	
Other vs Border Collie	0.703	
Other vs Mixed Breed	0.158	
Other vs Springer Spaniel	0.726	
Other vs Jack Russell Terrier	**0.001**	
Labrador Retriever vs Border Collie	0.790	
Labrador Retriever vs Mixed Breed	0.306	
Labrador Retriever vs Springer Spaniel	0.755	
Labrador Retriever vs Jack Russell Terrier	**0.003**	
Border Collie vs Mixed Breed	0.622	
Border Collie vs Springer Spaniel	0.845	
Border Collie vs Jack Russell Terrier	**0.015**	
Mixed Breed vs Springer Spaniel	0.991	
Mixed Breed vs Jack Russell Terrier	**0.014**	
Springer Spaniel vs Jack Russell Terrier	0.281	

2.3.12 OAD RE and breed; full OAD sample

The association between the top six most common breeds in the full OAD sample (49,428) returned from the regex, and being described with one of the five OAD REs is shown in Table 2.15.

Table 2.15: Chi-squared and logistic regression analysis of the six most common breeds being described with one of the five OAD REs within the full dog sample (49,428)

Outcome Variable	Yes, N (%)	Other OAD RE, N (%)	OR	(95% CI)	*P*
Ageing					
Other (23,202) (Reference)	773(3.3)	22,429(96.7)	**1.00**		**0.000**
Mixed Breed (10,758)	389(3.6)	10,369(96.4)	1.089	(0.962-1.232)	0.180
Labrador Retriever (5,681)	5432(95.6)	249(4.4)	**1.330**	(1.150-1.539)	**0.000**
Jack Russell Terrier (3,359)	137(4.1)	3,222(95.9)	**1.234**	(1.025-1.485)	**0.026**
Cocker Spaniel (2,541)	120(4.7)	2,421(95.3)	**1.438**	(1.181-1.751)	**0.000**
Border Collie (2,174)	104(4.8)	2,070(95.2)	**1.458**	(1.182-1.798)	**0.000**
Springer Spaniel (1,713)	82(4.8)	1,631(95.2)	**1.459**	(1.155-1.842)	**0.001**
Elderly					
Cocker Spaniel (2,541) (Reference)	113(4.4)	2,428(95.6)	**1.00**		**0.000**
Mixed Breed (10,758)	670(6.2)	10,088(93.8)	**1.427**	(1.163-1.750)	**0.001**
Labrador Retriever (5,681)	285(5.0)	5,396(95.0)	1.135	(0.908-1.418)	0.266
Jack Russell Terrier (3,359)	283(8.4)	3,076(91.6)	**1.977**	(1.579-2.474)	**0.000**
Border Collie (2,174)	123(5.7)	2,051(94.3)	1.289	(0.992-1.675)	0.058
Springer Spaniel (1,713)	97(5.7)	1,616(94.3)	1.290	(0.976-1.704)	0.073
Other (23,202)	1,332(5.7)	21,870(94.3)	**1.309**	(1.075-1.593)	**0.007**
Geriatric					
Mixed Breed (10,758) (Reference)	651(6.1)	10,107(93.9)	**1.00**		**0.000**
Labrador Retriever (5,681)	374(6.6)	5,307(93.4)	1.094	(0.959-1.248)	0.180
Jack Russell Terrier (3,359)	259(7.7)	3,100(92.3)	**1.297**	(1.117-1.506)	**0.001**
Cocker Spaniel (2,541)	176(6.9)	2,365(93.1)	1.155	(0.972-1.373)	0.101

Border Collie (2,174)	150(6.9)	2,024(93.1)	1.151	(0.957-1.383)	0.135
Springer Spaniel (1,713)	160(9.3)	1,553(90.7)	**1.600**	(1.335-1.917)	**0.000**
Other (23,202)	1,509(6.5)	21,693(93.5)	1.080	(0.982-1.187)	0.112
Old					
Springer Spaniel (1,713) (Reference)	1,066(62.2)	647(37.8)	**1.00**		**0.000**
Mixed Breed (10,758)	7,270(67.6)	3,448(32.4)	**1.265**	(1.138-1.406)	**0.000**
Labrador Retriever (5,681)	3,718(65.4)	1,963(34.6)	**1.150**	(1.028-1.286)	**0.015**
Jack Russell Terrier (3,359)	2,164(64.4)	1,195(35.6)	1.099	(0.974-1.240)	0.124
Cocker Spaniel (2,541)	1,693(66.6)	848(33.4)	**1.212**	(1.066-1.377)	**0.003**
Border Collie (2,174)	1,417(65.2)	757(34.8)	1.136	(0.996-1.296)	0.057
Other (23,202)	15,892(68.5)	7,310(31.5)	**1.319**	(1.192-1.461)	**0.000**
Senior					
Jack Russell Terrier (3,359) (Reference)	516(15.4)	2,843(84.6)	**1.00**		**0.000**
Mixed Breed (10,758)	1,778(16.5)	8,980(83.5)	1.091	(0.980-1.214)	0.110
Labrador Retriever (5,681)	1,055(18.6)	4,626(81.4)	**1.257**	(1.120-1.410)	**0.000**
Cocker Spaniel (2,541)	439(17.3)	2,102(82.7)	**1.151**	(1.001-1.323)	**0.048**
Border Collie (2,174)	380(17.5)	1,794(82.5)	**1.167**	(1.009-1.349)	**0.037**
Springer Spaniel (1,713)	308(18.0)	1,405(82.0)	**1.208**	(1.034-1.410)	**0.017**
Other (23,202)	3,696(15.9)	19,506(84.1)	1.044	(0.944-1.154)	0.400

In comparison to the Other breeds as a reference, the Labrador Retriever was 1.3 times more likely, Jack Russell Terrier 1.2 times, Cocker Spaniel 1.4 times, Border Collie 1.5 times, and the Springer Spaniel 1.5 times more likely to be described as ageing. In comparison to the Cocker Spaniel as a reference, the Mixed Breed was 1.4 times more likely to be described as elderly, the Jack Russell Terrier almost twice as likely, and Other breeds 1.3 times more likely. In comparison to the Mixed Breed as a reference, the Jack Russell Terrier was 1.3 times more likely to be described as geriatric, and the Springer Spaniel was 1.6 times more likely. In comparison to the Springer Spaniel as a

reference, the Mixed Breed was 1.3 times more likely to be described as old, the Labrador Retriever 1.2 times more likely, the Cocker Spaniel 1.2 times more likely, and Other breeds 1.3 times more likely. In comparison to the Jack Russell Terrier as a reference, the Labrador Retriever was 1.3 times more likely to be described as senior, the Cocker Spaniel 1.2 times more likely, the Border Collie 1.2 times more likely, and the Springer Spaniel 1.2 times more likely.

2.3.13 OAD RE and breed; OAD sub-sample

There was no evidence of an association between the most common breeds and being described with one of the five search OAD REs within the sub-sample of each OAD RE (Table 2.16).

Table 2.16: Chi-squared analysis and logistic regression of the six most common breeds being described with one of the five OAD REs in the OAD sub-sample (832)

Outcome Variable	Yes, N (%)	Other OAD RE, N (%)	OR	(95% CI)	*P*
Ageing					
Mixed Breed (180) (Reference)	38(21.1)	142 (78.9)	1.00		0.340
Labrador Retriever (108)	26(24.1)	82(75.9)	1.185	(0.671-2.091)	0.558
Jack Russell Terrier (60)	15(25.0)	45(75.0)	1.246	(0.628-2.472)	0.530
Cocker Spaniel (48)	14(29.2)	34(70.8)	1.539	(0.750-3.155)	0.239
Border Collie (47)	13(27.7)	34(72.3)	1.429	(0.687-2.972)	0.340
Springer Spaniel (36)	8(22.2)	28(77.1)	1.068	(0.450-2.532)	0.882
Other (353)	62(17.6)	291 (82.4)	0.796	(0.507-1.250)	0.322
Elderly					
Mixed Breed (180) (Reference)	35(19.4)	145(80.6)	1.00		0.156
Labrador Retriever (108)	18(16.7)	90(83.3)	0.829	(0.443-1.550)	0.556
Jack Russell Terrier (60)	18(30.0)	42(70.0)	1.776	(0.914-3.450)	0.090
Cocker Spaniel (48)	5(10.4)	43(89.6)	0.482	(0.178-1.305)	0.151
Border Collie (47)	6(12.8)	41(87.2)	0.606	(0.239-1.541)	0.293
Springer Spaniel (36)	6(16.7)	30(83.3)	0.829	(0.320-2.145)	0.698

Other (353)	76(21.5)	277 (78.5)	1.137	(0.726-1.779)	0.575
Geriatric					
Mixed Breed (180) (Reference)	34(18.9)	146(81.1)	1.00		0.291
Labrador Retriever (108)	28(25.6)	80(74.1)	1.503	(0.850-2.657)	0.161
Jack Russell Terrier (60)	11(18.3)	49(81.7)	0.924	(0.454-2.047)	0.924
Cocker Spaniel (48)	10(20.8)	38(79.2)	0.762	(0.513-2.491)	0.762
Border Collie (47)	11(23.4)	36(76.6)	0.490	(0.607-2.838)	0.490
Springer Spaniel (36)	13(36.1)	23(63.9)	0.025	(1.117-5.272)	0.025
Other (353)	90(25.5)	263(74.5)	0.089	(0.943-2.289)	0.089
Old					
Mixed Breed (180) (Reference)	30(16.7)	150(83.3)	1.00		0.182
Labrador Retriever (108)	17(15.7)	91(84.3)	0.934	(0.488-1.788)	0.837
Jack Russell Terrier (60)	5(8.3)	55(91.7)	0.455	(0.168-1.231)	0.121
Cocker Spaniel (48)	6(12.5)	42(87.5)	0.714	(0.279-1.830)	0.483
Border Collie (47)	8(17.0)	39(83.0)	1.026	(0.436-2.414)	0.954
Springer Spaniel (36)	1(2.8)	35(97.2)	0.143	(0.019-1.083)	0.060
Other (353)	38(10.8)	315(89.2)	0.603	(0.360-1.011)	0.055
Senior					
Mixed Breed (180) (Reference)	43(23.9)	137(76.1)	1.00		0.680
Labrador Retriever (108)	19(17.6)	89(82.4)	0.680	(0.372-1.242)	0.210
Jack Russell Terrier (60)	11(18.3)	49(81.7)	0.715	(0.342-1.496)	0.374
Cocker Spaniel (48)	13(27.1)	35(72.9)	1.183	(0.574-2.438)	0.648
Border Collie (47)	9(19.1)	38(80.9)	0.755	(0.338-1.685)	0.492
Springer Spaniel (36)	8(22.2)	28(77.8)	0.910	(0.386-2.145)	0.830
Other (353)	87(24.6)	266(75.4)	1.042	(0.685-1.585)	0.847

2.4 Discussion

Within the literature, there is a variety of definitions for an old age dog. Previous studies do not use one accepted definition, whether it be based on a sequential point or a physical measure, and so direct comparisons between findings cannot be easily made. Instead, the novel approach used in this project aimed to identify when a dog was defined as having reached old age according to the opinion of a veterinarian, through the words used to describe the dog in the EHR of the consultation. If a veterinarian decided to use one of these words to describe a dog, it was assumed that they had made observations leading them to categorise the patient within that life stage according to pre-conceived criteria which are distinct from the adult life stage; such observations might include, but be limited to, external observations, physical ailments, behavioural changes, and physiological measures. There was evidence that the common terms used in this study to identify OADs were used variably by veterinarians in consultations both in terms of their frequency, and to some extent the age of the animals, such that future studies would require inclusion of multiple terms rather than just relying on one. Important differences in the use of these terms between different sexes and between different breeds were identified, suggesting that such a method could provide a real-time and therefore up-to-date methodology to assess this important life stage in dogs.

Interestingly, the age at which the different OAD REs were used seemed to vary, with the word "senior" being used relatively early (youngest median for sub-sampled data, second youngest median for full data set), and "elderly" being used for older animals (oldest median in both data sets). This suggested that once a dog was beyond the adult life stage, veterinarians in this study population tended to use definitions in order; the word Senior at around 10.7y (IQR 8.60-13.02), Geriatric at 11.8y (IQR 10.39-13.63), and Elderly at 14.0y (IQR 12.64-15.14) (figures based on OAD sub-sample). It should also be noted that the difference in median age of the full data set (11.2y) compared to the sub-sample (12.5y), can be in part explained by the difference in median age of the

use of the ‘old’ OAD RE. In the full data set the median age of the ‘old’ OAD RE is 10.7y, compared to 12.9y in the sub-sample. The higher median age of the full data set can be explained due to containing false positives due to the lower accuracy of the ‘old’ OAD RE, therefore the sub-sample had a lower median age as each consultation was read to ensure accuracy and to mitigate this effect on the median age. This word ranking is broadly consistent within existing naming strategies that have defined senior at 7y and geriatric at 11y for dogs that weigh <22.7kg, and senior at 6y and geriatric at 9y for dogs weighing ≥22.7kg (Bellows et al. 2015b). In another approach, senior was defined as the last 25% of the estimated lifespan (Creevy et al. 2019). This either suggests that the animals in our study population are ageing later, or that the veterinarians contributing data to SAVSNET could start to use these words earlier in consultations in order to make owners more aware; this would allow the implementation of effective preventive healthcare at the earliest possibility thereby potentially slowing the progression of old age. However, it should be noted that the methodology used here captures the age of a dog at a consultation where the veterinarian uses one of the five chosen terms. As such, the ages presented are not the age of onset of old age, rather the age when they are considered to be in that age category. In future studies, it would be interesting to evaluate the onset of the use of these terms as a surrogate for the onset of old age. There is also no defined ‘elderly’ stage within the literature, but this work suggests that the term is being used and may refer to the oldest dogs seen in practice which display signs of progression beyond the typical old age dog which may be otherwise described as senior or geriatric.

Having defined a group of dogs in a state of old age, whether the use of the OAD REs by veterinarians was influenced by the dog type was investigated. These results may suggest that certain groups within the population are affected by ageing differently, and may, therefore, have different healthcare needs at different times. Although not evident in the sub-sampled data set, female entire dogs were significantly younger when referred to as old in the full data set. There were

also differences between breed and OAD RE use, which would imply that breeds reach stages of old age at different ages according to veterinarians. For example, in both data sets, Jack Russell Terriers were the oldest and Cocker Spaniels the youngest breeds. This is consistent with findings in a previous study which suggested that smaller dogs have a delayed onset of age-related diseases compared to larger breeds, and ultimately age at a slower rate than larger breeds (Kraus, Pavard & Promislow 2013).

Within this stage of the project, there were limitations encountered when designing the regular expressions. It was important to factor in spelling variations of the five OAD REs; however, it is unlikely that all variations would have been accounted for, which potentially allows for the exclusion of relevant consultations (false negatives) from the dataset used for analysis. It is also important to note that the regular expressions attempted to negate any irrelevant consultations, for example, the senior regular expression excluded the use of the term senior in relation to owners rather than dogs. Similarly, in some instances, the words may have been used in the context of a dog, but in consultations of young dogs and are therefore not truly old age dogs. In addition, the poorer accuracy of the 'old' regular expression may be attributed to the wide range of associated common negations, making the development of the regular expression intricate by attempting to incorporate all of these negations without systematically excluding any cases. For example, it may be useful to exclude 'old medication' in future studies, as this was found to be an inappropriate use of the word 'old' for the purposes of this project. That said, two of the OAD RE were of higher accuracy, such that in future studies it might be feasible to use all of the consultations found by the existing 'senior' and

'geriatric' OAD RE to explore the demographics of these populations at greater resolution and could be achieved by reading as both of these regexes had an approximate accuracy of 95% or above.

Clearly, the breed specific analyses conducted were informative in determining whether particular breeds are described as having reached old age sooner than other breeds. However, the sub-sampled population was not large enough to complete analysis for many different breeds. Future work using the fuller data set, perhaps excluding the lowest accurate regex for "old", may allow these analyses to be applied to a wider range of breeds and thereby inform more owners of the trends in onset of old age for their own dog, and the associated health issues of old age.

Overall, these findings can be considered as an alternative approach to define the senior life stages in dogs, based on veterinarian observations amongst different dog breeds. Our findings agree that a one size fits all approach may not be appropriate, as different dog breeds may be affected by ageing differently (Bellows et al. 2015b; Creevy et al. 2019). This means that different dog breeds may reach old age and begin to experience health signs and conditions differently, and therefore it is important to understand what these conditions are and when they occur so that appropriate preventive healthcare or treatment can be provided. In the next chapter the 832 consultations of the sub-sampled and validated data set are used to explore further the common health conditions that are recorded during consultations for this population of dogs presenting in old age.

Chapter Three: Categorisation of common issues

3.1 Introduction

Continuing the work reported in Chapter two, the next aim was to study common issues recorded in the consultations of the sub-sample of confirmed OADs which were previously extracted. This information could be used to inform owners of common issues and the signs to look out for, preventive measures to implement to reduce the prevalence, and effective treatment options that are available, should the issue occur.

A further aim was to analyse common issues to determine whether there are certain dog types (including breed and sex and neuter status) which are at increased risk of developing these issues. These findings can then be used to tailor health messaging more specifically, rather than using a uniform approach applied to all dog types which would not highlight specific differences.

Previous studies have investigated common issues in old age dogs. For example, common issues in old age dogs have found to be disorders such as osteoarthritis, skin mass and lipomas, and heart murmurs (O'Neill et al., 2021). In dogs aged over 7 years old, dermatitis and otitis externa were common issues, and for dogs older than 10 years old, heart disease and kidney disease were found to be common (Kim et al., 2018). In addition, 100 senior and geriatric dogs which were thought to be healthy by their owners, were physically examined and found to have health issues. This included 56 dogs which had at least 1 (sub)cutaneous mass, 39 dogs were found to be overweight, 22 were found to have a heart murmur, and 21 dogs were found to have severe calculus, amongst other observations (Willems, 2017).

Owners had previously thought these dogs to be healthy, highlighting the importance of making owners aware of signs to look out for as their dog ages. By identifying the common issues in old age

dogs recorded within the data of this study, and the particular dog types most at risk, the relevant information can be communicated to owners. Such efforts may contribute to ensuring adequate health of old age dogs as they are living longer.

3.2 Methods

Data consisted of EHRs of 832 'old age dogs' extracted from SAVSNET (Chapter two). In brief, this dataset contained 832 consultations (the OAD sub-sample) including 176 found by the 'ageing' regex (21.15%), 164 by 'elderly' (19.71%), 197 by 'geriatric' (23.68%), 105 by 'old' (12.62%), and 190 by 'senior' (22.84%) regexes. This sub-sample of 832 vet visiting OAD dogs was 51% female (427) and 49% male (405), and had all been read by the author to ensure they were with old age animals and excluded those any false positives.

3.2.2 Dog-specific data extraction and categorisation of information recorded in consultations

For each of these 832 consultations with OADs, the free text written by the attending practitioner was read to identify the main issues recorded at presentation to primary practice based on a modified version of the World Health Organisation (WHO) International Statistical Classification of Diseases and Related Health Problems (ICD) ICD-10 system (WHO 2010). The ICD10 clinical classifications were adapted to include travel, microchipping, behaviour, weight, euthanised and other. The latter other category was included to identify those consultations where no problems were recorded ("no features found"), and for each OAD RE ("search word"); for example, consultations were categorised as 'senior' where the dog presented in the consultation was described unequivocally as 'being of old age' by the practitioner, or where products/services associated with OADs were discussed (e.g. senior biochemistry profiles, senior diets, and/or medication). The final list of categories used is shown in Table 3.1; in the rest of this work, and to distinguish from the original ICD10 system of classifiers, these are referred to as "categories".

During subsequent categorisation, each consultation identified by the OAD RE was allowed to have zero to multiple complaints based on what was recorded in the free text. For each, using Datalab functionality, the minimum phrase (text string) required to identify any disease process was manually highlighted in the free text of the clinical narrative to categorise this text string to that category. For example, where a vet writes “vomiting twice yesterday”, the word ‘vomiting’ was highlighted by the author and associated with the Digestive category. Both diagnoses and clinical signs were categorised in this way. Where a dog had a single suspected diagnosis recorded by the attending practitioner, this was categorised. However, if a dog had multiple suspected diagnoses, these were not categorised. This assumed that a veterinarian would record a single suspected diagnosis with greater confidence, in comparison to less confidence in diagnoses if the veterinarian had suggested more than one possibility. Additional examples of clinical text and their chosen categories are shown in Table 3.2.

Table 3.1: Categories used to categorise consultation notes in this project (Modified categories), and how they relate to the existing World Health Organisation (WHO) International Statistical Classification of Diseases and Related Health Problems (ICD) ICD-10 system (WHO 2010).

M*odified Categories used in this project*	WHO I*CD-10 classifiers*
Euthanised	N/A
Auditory (middle, inner ear)	Diseases of the ear and mastoid process
Behaviour	N/A
Cardiopulmonary (coughing, sneezing, murmur, oedema)	Diseases of the circulatory system Diseases of the respiratory system
Dental	Diseases of the digestive system
Digestive (excluding teeth and anal glands; including lips as well as tongue to anus)	Diseases of the digestive system
Endocrine (including DM, Cushing's, hypothyroidism etc.)	Endocrine, nutritional and metabolic diseases
Immunological (including vaccine discussion)	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism
Integumentary (including external ear, otitis externa, nails and anal glands)	Diseases of the skin and subcutaneous tissue
Microchip (checked or given)	N/A
Musculoskeletal (e.g. osteoarthritis, lameness)	Diseases of the musculoskeletal system and connective tissue
Neoplasia	Neoplasms
Neurological (including knuckling)	Diseases of the nervous system
Ocular (including periocular skin, entropion/ectropion)	Diseases of the eye and adnexa
Parasites (discussed or seen)	Certain infectious and parasitic diseases
Reproductive (include discussion of neutering)	Diseases of the genitourinary system
Travel	N/A
Urinary (infection, polyuria, incontinence)	Diseases of the genitourinary system
Weight	Endocrine, nutritional and metabolic diseases
No Features Found	N/A
Other	Clinical signs, and abnormal clinical and laboratory findings, not elsewhere classified
OAD RE	N/A

Table 3.2: Examples of text which indicated allocation to the appropriate category. Text is reproduced verbatim with occasional original spelling mistakes.

Category	Text
Dental	moderate degree of calculus evident and halitosis
	really bad teeth, some of them are attasched just by tartar. Really bad smelling mouth. Really old and may not be a good option to do scale and polish due to GA.
	Dental extractions due to severe periodontal disease. Watch mandib carnass (309) and maxill canine (204) extraction sites as risk of fracture or oronasal fistula formation.
	103,203 removed as unstable rest upper incisors missing; 403,402,302,303 removed as unstable; rest lower incisors missing; 104,204 removed as unstable, gingival hyperplasia
Musculoskeletal	Lame RH. Has been intermittently lame on RH, stooping down on ambulation, worse some days and in the mornings. Unusual gait and sloped appearance to hips.
	some arthritis left fore, right hip mainly. chews at left elbow. didnt react particualry to me manipulating joints, but can fell some clunk/crepitus.
	owner reports sometimes on walk limps and places paw up, owner thinks could be nails? advise possible is nine now onset of arthritis?
	OR that off back legs yesterday. very tender in lumbar spine, reduced knuckling reflex on LH. Just wanting to sit. very elderly and extensive muscle wastage.
Weight	Discuss weight/feeding - sounds like human food given! Already on senior diet
	is also overweight despite being fed a sensible diet of a light senior dry food and no treats
	not gained weight, looks thinner, but weight stable at 13.2kg.

Once all 832 records had been categorised in this way, the resulting categories and highlighted text strings were further manually collated into sub-categories in an inductive and iterative fashion (Microsoft Excel). For example, the text strings “vomiting”, “vomited” and “v++” were ultimately manually assigned to a single sub-category vomiting. In this way, each consultation could be described by a series of one or more categories, each with their associated sub-category (e.g. Table 3.3). A first round of sub-categorisation was completed by the first author, and included 96% of consultations where categorisation was felt to be unequivocal. The remaining 4% were less clear and were sub-categorised together with an experienced researcher and veterinarian.

Table 3.3: Examples of text which indicated allocation to the appropriate sub-category. Text is reproduced verbatim with occasional spelling mistakes.

Category	Sub-Category	Text
Dental	Tartar	Mild tartar reforming dental few years ago.
		tartar. Dental care advised: brush teeth
		tartar build up over upper canines and molars, advised tooth brushing / book in for dental before reaching older age.
		marked tartar and periodontal disease advise GA dental but obviously risk.
	Gingivitis	Some gingivitis upper left caudally
		Some gingivitis aroudn caudal teeth.
		Generalised moderate gingivitis
Musculoskeletal	Stiff	stiffness sometimes. discusssed OA checklist.
		O says stiff when gets up but improves when gets going. Mobility generally not great. Obesity major factor in this
		Stiffness RHL on rising occasionally. Suspect OA, adv supplements and senior diet, NSAIDs in due course.
		can run around quite spritely but there is a limit and will get very stiff afterwards.
	Lameness	Lameness well under control with the onsior.
		OA examination. Very lame v elderly dog.
		Now slightly lame shortly after getting up in mornings as well as w/ exercise. Not lame on rising, just afterwards.
Weight	Weight Loss	Owner noticing weight loss.
		Weight loss over several months 3kg since 9/13. Generally emaciated condition
		weight loss - appears to have stabilised
		he keeps loosing weight that is worrying at this stage.
	Ideal – BCS Recorded	29.2kg. gained 1.6kg. body condition score 4-5/9 so ok but to watch this, prob related to food change
		BCS ideal-5
		BCS: Consistent. Body condition score 4-5/9.

3.2.3 Statistical methods

The association between the continuous measure of age and categorical variables (old age terminology used by the vet, breed, sex/neuter status, modified ICD-10 category) was explored using pairwise comparisons and the Kruskal-Wallis test, with post-hoc comparisons conducted using Dunn's tests. The association between categorical outcomes (categories recorded in health narratives) and variables (such as breed, OAD RE, and sex/neuter status) was assessed using the chi-squared test and binary logistic regression. The frequency of dogs recorded within the top five categories was compared for each of the OAD RE through a chi-squared test and binary logistic

regression. Within the logistic regression, for each OAD RE, the reference category was set at the lowest, for breed the reference was chosen based on the breed with the lowest odds ratio when univariable modelling was performed using Mixed Breed as an initial reference. Multivariable binary logistic modelling was then performed to investigate factors associated with ICD-10 categorisation outcomes (for the top five ICD10 categories: digestive, dental, integument, musculoskeletal and weight), using fixed effects including age, OAD RE, breed, sex, neuter status, and sex and neuter status combined. Modelling consisted of Model 1 (sex and neuter status combined to form four "sexes") to account for differences in sex and neuter status and how they interact; and Model 2 (sex and neuter status as separate variables) to model sex and neuter status independently. The probability level of $P \leq 0.05$ (two-sided) was used to indicate whether or not there was a statistical significance in these findings. The analyses were performed using the SPSS data software package (SPSS version 26.0, IBM Corp.).

3.3 Results

3.3.1 Disease categorisation

Among the 832 consultations analysed, 2,292 complaints were identified that could be assigned to categories and sub-categories. The five most common categories recorded in the health narratives of OADs were dental (254 of 832 consultations, 30.5%), digestive (187, 22.5%), integument (235, 28.2%), musculoskeletal (278, 33.4%) and weight (289, 34.7%). A distribution of the 2,292 complaints within the modified ICD-10 categories can be seen below (Figure 3.1). A descriptive summary of all categories for the most common breeds (N>10) can be found in the appendices (Appendix A).

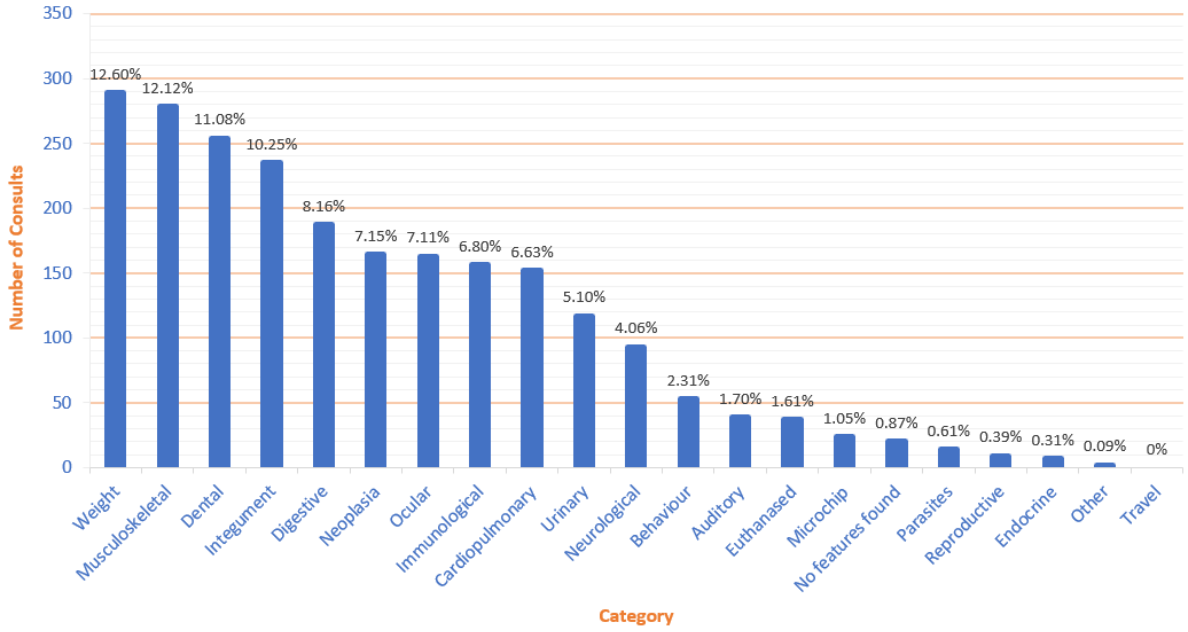

Figure 3.1: Distribution of 2,292 issues (complaints) identified in 832 OADs presenting to practice according to the modified ICD-10 categorisation system. The indicated percent for each category is expressed in relation to the total number of 2,292 complaints that were identified in the 832 consultations analysed.

3.3.2 ICD-10 categorisation and OAD RE

There was evidence of a statistically-significant association between being described as one of the five old age descriptor words and being recorded as presenting with a digestive issue (*P*<0.001; Table 3.5). Only 11.9% (21) of ageing dogs had digestive issues. In comparison, 25.6% (42) of elderly dogs, 19.8% (39) of geriatric dogs, 22.9% (24) of old dogs, and 32.1% (61) of senior dogs were recorded as presenting with a digestive issue. Overall, in comparison to ageing as a reference category, dogs with a digestive issue were more likely to be described as senior (OR=3.490, 95%CI (2.017-6.038), *P*=0.000), elderly (OR=2.541, 95%CI (1.430-4.516), *P*=0.001), geriatric (OR=1.822, 95%CI (1.025-3.237), *P*=0.041), and old (OR=2.187, 95%CI (1.148-4.166), *P*=0.017) by a veterinarian. There was also evidence of a statistically significant association between being described as one of the five descriptor words of old age and being recorded as presenting with a weight issue (*P*<0.001). Weight issues were evident in 25.6% (45) of ageing dogs. In comparison, 29.9% (49) of elderly dogs, 32.5%

(64) of geriatric dogs, 31.4% (33) of old dogs, and 51.6% (98) of senior dogs presented with a weight issue. Overall, in comparison to ageing as a reference category, dogs with a weight issue were more likely to be described as senior (OR=3.101, 95%CI (1.993-4.826), *P*=0.000) by a veterinarian. There was no further evidence of an association between being described as old age and being recorded as presenting with any of the other common issues.

3.3.3 ICD-10 category and breed

The percentage of each breed recorded as presenting with dental issues was: Cocker Spaniel (23, 47.9%), Jack Russell Terrier (25, 41.7%), Other (104, 29.5%), Labrador Retriever (31, 28.7%), Border Collie (13, 27.7%), Mixed Breed (49, 27.2%), and Springer Spaniel (9, 25.7%) (Table 3.6). Overall, in comparison to the Mixed Breed as a reference, of the most common breeds, the Cocker Spaniel was more than twice as likely to be recorded as presenting to practice with a dental issue (OR=2.460, 95%CI (1.278-4.733), *P*=0.007), and the Jack Russell Terrier was almost twice as likely (OR=1.910, 95%CI (1.038-3.512), *P*=0.037). There was also evidence of an association between the six most common breeds and being diagnosed with musculoskeletal issues (*P*=0.002). In comparison to the Mixed Breed as a reference, the Cocker Spaniel was less than half as likely to be recorded as presenting to practice for a musculoskeletal issue (OR=0.346, 95%CI (0.158-0.758), *P*=0.008), and Other breeds were approximately half as likely (OR=0.593, 95%CI (0.406-0.865), *P*=0.007). There was no further evidence of an association between the most common breeds and being recorded as presenting with any of the other common issues.

Table 3.5: Chi-squared analysis and logistic regression of the association between the five most common issues and the five OAD RE in the OAD sub-sample (832)

Outcome Variable	Yes, N (% within OAD RE)	No, N (% within OAD RE)	OR	(95% CI)	*P*
Dental					
Ageing (176) (Reference)	53(21.3)	123(69.9)	1.00		0.994
Elderly (164)	51(31.1)	113(68.9)	1.047	(0.660-1.662)	0.884
Geriatric (197)	59(29.9)	138(70.1)	0.992	(0.637-1.546)	0.972
Old (105)	31(29.5)	74(70.5)	0.972	(0.537-1.650)	0.917
Senior (190)	60(31.6)	130(68.4)	1.071	(0.687-1.670)	0.762
Digestive					
Ageing (176) (Reference)	21(11.9)	155(88.1)	**1.00**		**0.000**
Elderly (164)	42(25.6)	122(74.4)	**2.541**	(1.430-4.516)	**0.001**
Geriatric (197)	39(19.8)	158(80.2)	**1.822**	(1.025-3.237)	**0.041**
Old (105)	24(22.9)	81(77.1)	**2.187**	(1.148-4.166)	**0.017**
Senior (190)	61(32.1)	129(67.9)	**3.490**	(2.017-6.038)	**0.000**
Integument					
Ageing (176) (Reference)	44(25.0)	132(75.0)	1.00		0.345
Elderly (164)	43(26.2)	121(73.8)	1.066	(0.655-1.736)	0.797
Geriatric (197)	62(31.5)	135(68.5)	1.378	(0.874-2.171)	0.167
Old (105)	36(34.3)	69(65.7)	1.565	(0.923-2.654)	0.096
Senior (190)	50(26.3)	140(73.7)	1.071	(0.670-1.714)	0.773
Musculoskeletal					
Ageing (176) (Reference)	52(29.5)	124(70.5)	1.00		0.651
Elderly (164)	60(36.6)	104(63.4)	1.376	(0.874-2.166)	0.168
Geriatric (197)	70(35.5)	127(64.5)	1.314	(0.850-2.032)	0.219
Old (105)	35(33.3)	70(66.7)	1.192	(0.709-2.004)	0.507
Senior (190)	61(32.1)	129(67.9)	1.128	(0.723-1.759)	0.596
Weight					
Ageing (176) (Reference)	45(25.6)	131(74.4)	**1.00**		**0.000**
Elderly (164)	49(29.9)	115(70.1)	1.240	(0.771-1.996)	0.375
Geriatric (197)	64(32.5)	133(67.5)	1.401	(0.892-2.200)	0.143
Old (105)	33(31.4)	72(68.6)	1.334	(0.783-2.274)	0.289
Senior (190)	98(51.6)	92(48.4)	**3.101**	(1.993-4.826)	**0.000**

Table 3.6: Chi-squared analysis and logistic regression of the six most common breeds recorded as presenting with the five most common issues in the OAD sub-sample (832)

Outcome Variable	Yes, N (%)	No, N (%)	OR	(95% CI)	*P*
Dental					
Mixed Breed (180) (Reference)	49(27.2)	131(72.8)	**1.00**		**0.063**
Labrador Retriever (108)	31(28.7)	77(71.3)	1.076	(0.633-1.830)	0.786
Jack Russell Terrier (60)	25(41.7)	35(58.3)	**1.910**	(1.038-3.512)	**0.037**
Cocker Spaniel (48)	23(47.9)	25(52.1)	**2.460**	(1.278-4.733)	**0.007**
Border Collie (47)	13(27.7)	34(72.3)	1.022	(0.498-2.097)	0.952
Springer Spaniel (36)	9(25.7)	26(74.3)	0.891	(0.391-2.029)	0.784
Other (353)	104(29.5)	249(70.5)	1.117	(0.748-1.666)	0.589
Digestive					
Mixed Breed (180) (Reference)	40(22.2)	140(77.8)	1.00		0.684
Labrador Retriever (108)	17(15.7)	91(84.3)	0.654	(0.350-1.223)	0.183
Jack Russell Terrier (60)	15(25.0)	45(75.0)	1.167	(0.590-2.307)	0.658
Cocker Spaniel (48)	11(22.9)	37(77.1)	1.041	(0.487-2.223)	0.918
Border Collie (47)	12(25.5)	35(74.5)	1.200	(0.570-2.525)	0.631
Springer Spaniel (36)	7(19.4)	29(80.6)	0.845	(0.344-2.072)	0.713
Other (353)	187(22.5)	645(77.5)	1.110	(0.724-1.703)	0.632
Integument					
Mixed Breed (180) (Reference)	48(26.7)	132(73.3)	1.00		0.573
Labrador Retriever (108)	32(29.6)	76(70.4)	1.158	(0.682-1.965)	0.587
Jack Russell Terrier (60)	17(28.3)	43(71.7)	1.087	(0.567-2.086)	0.801
Cocker Spaniel (48)	13(27.1)	35(72.9)	1.021	(0.499-2.093)	0.954
Border Collie (47)	9(19.1)	38(80.9)	0.651	(0.293-1.447)	0.292
Springer Spaniel (36)	7(19.4)	29(80.6)	0.664	(0.273-1.615)	0.366
Other (353)	109(30.9)	244(69.1)	1.228	(0.823-1.833)	0.313
Musculoskeletal					
Mixed Breed (180) (Reference)	72(40.0)	108(60.0)	**1.00**		**0.002**
Labrador Retriever (108)	48(44.4)	60(55.6)	1.200	(0.741-1.944)	0.459
Jack Russell Terrier (60)	17(28.3)	43(71.7)	0.593	(0.314-1.120)	0.107
Cocker Spaniel (48)	9(18.8)	39(81.3)	**0.346**	(0.158-0.758)	**0.008**
Border Collie (47)	16(34.0)	31(66.0)	0.774	(0.395-1.518)	0.456
Springer Spaniel (36)	16(44.4)	20(55.6)	1.200	(0.583-2.470)	0.621
Other (353)	100(28.3)	253(71.7)	**0.593**	(0.406-0.865)	**0.007**
Weight					
Mixed Breed (180) (Reference)	65(36.1)	115(63.9)	1.00		0.511
Labrador Retriever (108)	38(35.2)	70(64.8)	0.960	(0.583-1.581)	0.874
Jack Russell Terrier (60)	16(26.7)	44(73.3)	0.643	(0.337-1.230)	0.182
Cocker Spaniel (48)	22(45.8)	26(54.2)	1.497	(0.786-2.851)	0.220
Border Collie (47)	17(36.2)	30(63.8)	1.003	(0.514-1.956)	0.994
Springer Spaniel (36)	10(27.8)	26(72.2)	0.680	(0.309-1.500)	0.340
Other (353)	121(34.3)	232(65.7)	0.923	(0.634-1.343)	0.675

3.3.4 ICD-10 categorisation and age

There was evidence of a difference of age at which dogs were recorded as having presented with each issue between weight vs musculoskeletal, weight vs dental, integument vs musculoskeletal, and integument vs dental (*P*<0.001, Figure 3.2, Table 3.7).

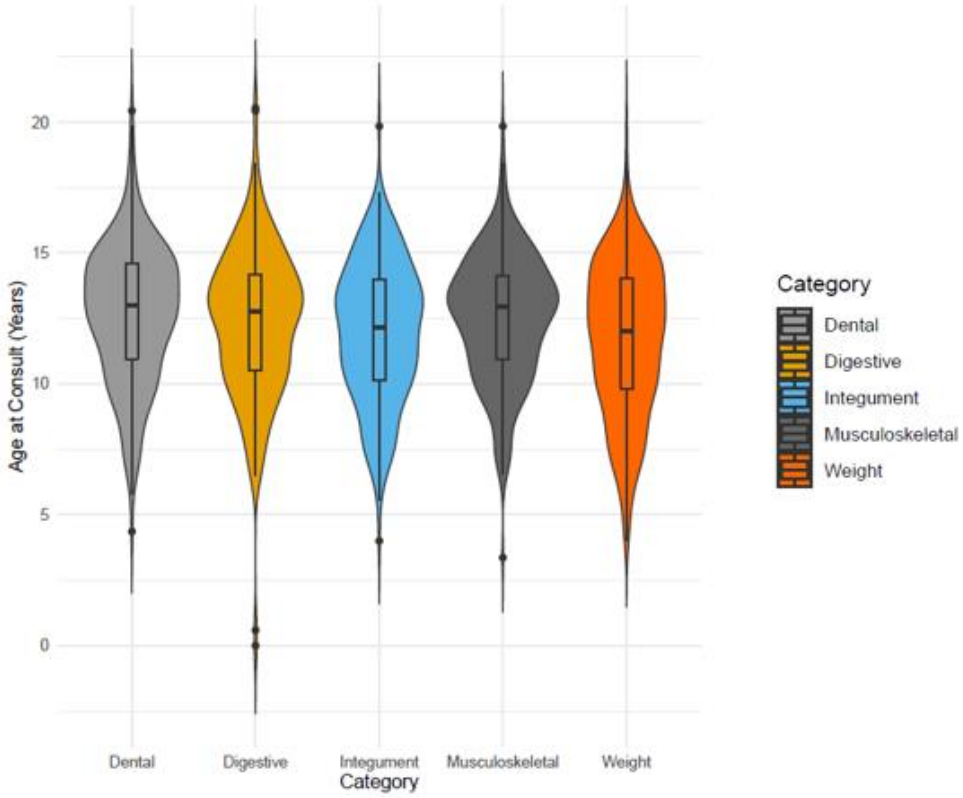

Figure 3.2: Violin plots showing the age distributions of dogs which were recorded as presenting with the five most common categories (1,243 consultations).

Table 3.7: Pairwise comparison of median age at consultation of dogs recorded with the top five issues in the OAD sub-sample (1,243), independent samples Kruskal Wallis test

Issue	Median Age (Years)
Dental	13.00
Digestive	12.78
Integument	12.15
Musculoskeletal	12.95
Weight	12.00

Issues Compared	*P* Value Pairwise	*P* Value Total
Weight vs Integument	0.391	0.001
Weight vs Digestive	0.022	
Weight vs Musculoskeletal	**0.001**	
Weight vs Dental	**0.000**	
Integument vs Digestive	0.154	
Integument vs Musculoskeletal	**0.028**	
Integument vs Dental	**0.005**	
Digestive vs Musculoskeletal	0.563	
Digestive vs Dental	0.244	
Musculoskeletal vs Dental	0.506	

3.3.5 ICD-10 Categorisation age of presentation and breed

There was evidence that the most common breeds differed in median age at consultation for musculoskeletal (*P*<0.01, Table 3.8), dental (*P*=0.039, table 3.9) issues, and digestive (*P*=0.001, table 3.10) issues.

Table 3.8: Musculoskeletal issues. Pairwise comparison of median age at consultation of the six most common and other breeds when recorded as presenting with musculoskeletal issues in the OAD sub-sample (278), independent samples Kruskal Wallis test

Breed	Median Age (Years)
Mixed Breed	13.10
Labrador Retriever	12.15
Jack Russell Terrier	15.09
Cocker Spaniel	12.14
Border Collie	12.99
Springer Spaniel	13.36
Other	12.73

Breed	*P* Value Pairwise	*P* Value Total
Cocker Spaniel vs Labrador Retriever	0.913	0.000
Cocker Spaniel vs Other	0.619	
Cocker Spaniel vs Springer Spaniel	0.369	
Cocker Spaniel vs Border Collie	0.228	
Cocker Spaniel vs Mixed Breed	0.347	
Cocker Spaniel vs Jack Russell Terrier	**0.001**	
Labrador Retriever vs Other	0.447	
Labrador Retriever vs Springer Spaniel	0.116	
Labrador Retriever vs Border Collie	0.246	
Labrador Retriever vs Mixed Breed	0.116	
Labrador Retriever vs Jack Russell Terrier	**0.000**	
Other vs Mixed Breed	0.303	
Other vs Springer Spaniel	0.455	
Other vs Border Collie	0.222	
Other vs Jack Russell Terrier	**0.000**	
Springer Spaniel vs Border Collie	0.718	
Springer Spaniel vs Mixed Breed	0.939	
Springer Spaniel vs Jack Russell Terrier	**0.003**	
Border Collie vs Mixed Breed	0.539	
Border Collie vs Jack Russell Terrier	**0.009**	
Mixed Breed vs Jack Russell Terrier	**0.000**	

Table 3.9: Dental issues. Pairwise comparison of median age at consultation of the most common breeds when recorded as presenting with dental issues in the OAD sub0sample (254), independent samples Kruskal Wallis test

Breed	Median Age (Years)
Mixed Breed	13.72
Labrador Retriever	12.34
Jack Russell Terrier	14.35
Cocker Spaniel	12.49
Border Collie	13.03
Springer Spaniel	13.16
Other	12.76

Breed	*P* Value Pairwise	*P* Value Total
Cocker Spaniel vs Labrador Retriever	0.998	0.039
Cocker Spaniel vs Other	0.505	
Cocker Spaniel vs Springer Spaniel	0.169	
Cocker Spaniel vs Border Collie	0.366	
Cocker Spaniel vs Mixed Breed	**0.049**	
Cocker Spaniel vs Jack Russell Terrier	**0.015**	
Labrador Retriever vs Other	0.454	
Labrador Retriever vs Springer Spaniel	0.153	
Labrador Retriever vs Border Collie	0.344	
Labrador Retriever vs Mixed Breed	**0.030**	
Labrador Retriever vs Jack Russell Terrier	**0.009**	
Other vs Border Collie	0.587	
Other vs Mixed Breed	**0.047**	
Other vs Springer Spaniel	0.265	
Other vs Jack Russell Terrier	0.013	
Springer Spaniel vs Border Collie	0.599	
Springer Spaniel vs Mixed Breed	0.905	
Springer Spaniel vs Jack Russell Terrier	0.675	
Border Collie vs Mixed Breed	0.554	
Border Collie vs Jack Russell Terrier	0.253	
Mixed Breed vs Jack Russell Terrier	0.402	

Table 3.10: Digestive issues. Pairwise comparison of median age at consultation of the most common breeds when recorded as presenting with digestive issues in the OAD sub-sample (187), independent samples Kruskal Wallis test

Breed	Median Age (Years)
Mixed Breed	13.90
Labrador Retriever	12.97
Jack Russell Terrier	14.35
Cocker Spaniel	11.52
Border Collie	12.56
Springer Spaniel	11.26
Other	12.03

Breed	*P* Value Pairwise	*P* Value Total
Cocker Spaniel vs Other	0.390	0.001
Cocker Spaniel vs Labrador Retriever	0.203	
Cocker Spaniel vs Springer Spaniel	0.424	
Cocker Spaniel vs Border Collie	0.143	
Cocker Spaniel vs Mixed Breed	**0.003**	
Cocker Spaniel vs Jack Russell Terrier	**0.009**	
Other vs Springer Spaniel	0.777	
Other vs Labrador Retriever	0.414	
Other vs Border Collie	0.276	
Other vs Mixed Breed	**0.000**	
Other vs Jack Russell Terrier	**0.007**	
Labrador Retriever vs Springer Spaniel	0.813	
Labrador Retriever vs Border Collie	0.753	
Labrador Retriever vs Mixed Breed	0.074	
Labrador Retriever vs Jack Russell Terrier	0.126	
Springer Spaniel vs Border Collie	0.637	
Springer Spaniel vs Mixed Breed	0.129	
Springer Spaniel vs Jack Russell Terrier	0.157	
Border Collie vs Mixed Breed	0.227	
Border Collie vs Jack Russell Terrier	0.274	
Mixed Breed vs Jack Russell Terrier	0.932	

The median age of dogs recorded with musculoskeletal issues was 13.0y. The median age of each breed when recorded with musculoskeletal issues was as follows; Mixed Breed (13.10y), Labrador Retriever (12.15y), Jack Russell Terrier (15.09y), Cocker Spaniel (12.14y), Border Collie (12.99y), Springer Spaniel (13.36y), Other (12.73y). There was evidence of a difference in age at which different breeds of dogs were recorded to have been presented for this issue (P<0.001; Table 3.8). Including Cocker Spaniel vs Jack Russell Terrier, Labrador Retriever vs Jack Russell Terrier, Mixed Breed vs Jack Russell Terrier, Other vs Jack Russell Terrier, Springer Spaniel vs Jack Russell Terrier, and Border Collie vs Jack Russell Terrier.

The median age of dogs recorded as presenting with dental issues was 13.0y. The median age of each breed when recorded with dental issues was follows; Mixed Breed (13.72y), Labrador Retriever (12.34y), Jack Russell Terrier (14.35y), Cocker Spaniel (12.49y), Border Collie (13.03y), Springer Spaniel (13.16y), Other (12.76y). There was evidence of a difference in the age at which different breeds of dog were recorded with dental issues (*P*=0.039; Table 3.9); including Labrador Retriever vs Mixed Breed, Labrador Retriever vs Jack Russell Terrier, Cocker Spaniel vs Jack Russell Terrier, Cocker Spaniel vs Mixed Breed, and Other vs Mixed Breed.

The median age of dogs recorded as presenting with digestive issues was 12.8y. The median age of each breed when recorded with digestive issues was as follows; Mixed Breed (13.90y), Labrador Retriever (12.97y), Jack Russell Terrier (14.35y), Cocker Spaniel (11.52y), Border Collie (12.56y), Springer Spaniel (11.26y), Other (12.03y). There was evidence of a difference in the age at which different breeds of dog were recorded as being presented for digestive issues (P=0.001; Table 3.10); including Cocker Spaniel vs Mixed Breed, Cocker Spaniel vs Jack Russell Terrier, Other vs Mixed Breed, and Other vs Jack Russell Terrier (*P*=0.001).

The median age of dogs recorded with integument issues was 12.2y. The median age of each breed when recorded with integument issues was as follows; Mixed Breed (12.82y), Labrador Retriever (11.42y), Jack Russell Terrier (14.01y), Cocker Spaniel (11.4y), Border Collie (14.64y), Springer Spaniel

(12.15y), Other (11.83y). There was no evidence of a difference in the age at which different breeds of dog were recorded to have been presented for this integument issues (*P*=0.057) (data not presented). The median age for dogs recorded with weight issues was 12.0y. The median age of each breed when recorded with weight issues was as follows; Mixed Breed (13.20y), Labrador Retriever (11.58y), Jack Russell Terrier (11.16y), Cocker Spaniel (11.64y), Border Collie (12.01y), Springer Spaniel (11.56y), Other (11.73y). There was no evidence of a difference in the age at which different breeds of dog were recorded for this issue (*P*=0.071) (data not presented).

3.3.6 ICD-10 category and sex/neuter status

There was no evidence of an association between presenting for one of the five most common issues and the four sex/neuter combinations (Table 3.11). Within each of the 5 major disease categories, there was no evidence of a difference in age for each sex (data not presented).

3.3.7 Multivariable binary logistic regression model of ICD-10 categorisation

Within the dental multivariable modelling, with every year of age, there was a ~10% increase in the odds of dental issues (OR=1.133, 95% CI 1.065-1.206, *P*=0.000). Significant associations were identified between breed and the presence of dental issues: for example, Cocker Spaniels had ~2.7 times (OR=2.710, 95% CI 1.383-5.309, *P*=0.004) the odds of dental issues compared with the reference breed (Mixed Breed) dogs (Table 3.12). There was also a positive association between sex and neuter status and the odds of dental issues, as sexually intact females were at greater odds (OR=1.641, 95% CI 1.149-2.343, *P*=0.006) than sexually-intact males.

Table 3.11: Chi-squared analysis and logistic regression of the association between being recorded as having one of the five most common issues and sex/neuter status in the OAD sub-sample (832)

Outcome Variable	Yes, N (%)	Other issue, N (%)	OR	95% CI	*P*
Dental					
Sexually Intact Male (120) (Reference)	40 (33.3)	80 (66.7)	1.00		0.055
Male Neutered (285)	100 (35.1)	185 (64.9)	1.081	(0.689-1.697)	0.735
Sexually Intact Female (98)	31 (31.6)	67 (68.4)	0.925	(0.523-1.637)	0.790
Female Neutered (329)	83 (25.2)	246 (74.8)	0.675	(0.429-1.062)	0.089
Digestive					
Sexually Intact Male (120) (Reference)	26 (21.7)	94 (78.3)	1.00		0.317
Male Neutered (285)	69 (24.2)	216 (75.8)	1.155	(0.692-1.927)	0.581
Sexually Intact Female (98)	15 (15.3)	83 (84.7)	0.653	(0.324-1.317)	0.234
Female Neutered (329)	77 (23.4)	252 (76.6)	1.105	(0.668-1.828)	0.698
Integument					
Sexually Intact Male (120) (Reference)	26 (21.7)	94(78.3)	1.00		0.359
Male Neutered (285)	83 (29.1)	202 (70.9)	1.486	(0.898-2.459)	0.124
Sexually Intact Female (98)	27 (27.6)	71 (72.4)	1.375	(0.739-2.557)	0.315
Female Neutered (329)	99 (30.1)	230 (69.9)	1.556	(0.949-2.551)	0.079
Musculoskeletal					
Sexually Intact Male (120) (Reference)	43 (35.8)	77 (64.2)	1.00		0.093
Male Neutered (285)	107 (37.5)	178 (62.5)	1.076	(0.691-1.677)	0.745
Sexually Intact Female (98)	24 (24.5)	74 (75.5)	0.581	(0.321-1.050)	0.072
Female Neutered (329)	104 (31.6)	225 (68.4)	0.828	(0.533-1.285)	0.399
Weight					
Sexually Intact Male (120) (Reference)	44 (36.7)	76 (63.3)	1.00		0.364
Male Neutered (285)	91 (31.9)	194 (68.1)	0.810	(0.518-1.267)	0.356
Sexually Intact Female (98)	30 (30.6)	68 (69.4)	0.762	(0.432-1.345)	0.348
Female Neutered (329)	124 (37.7)	205 (62.3)	1.045	(0.678-1.611)	0.843

Table 3.12: Dental disease. Logistic regression analyses of factors associated with dental ICD-10 categorisation in the OAD sub-sample

Model 1: N = 832. Hosmer-Lemeshow = 0.296. Adjusted model for age, OAD RE, breed, sex and neuter status.

Model 2: N = 832. Hosmer-Lemeshow = 0.437. Adjusted model for age, OAD RE, breed, sex, and neuter status.

Variable			**Unadjusted**			**Model 1**			**Model 2**		
			OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Age at time of consult (years)			**1.103**	(1.043-1.167)	**0.001**	**1.133**	(1.065-1.206)	**0.000**	**1.133**	(1.064-1.206)	**0.000**
OAD RE	Yes, N (%)	No, N (%)									
Ageing **(Reference)**	53(21.3)	123(69.9)	1.00		0.994	1.00		0.579	1.00		0.580
Elderly	51(31.1)	113(68.9)	1.047	(0.660-1.662)	0.844	0.878	(0.540-1.435)	0.597	0.877	(0.540-1.424)	0.597
Geriatric	59(29.9)	138(70.1)	0.992	(0.637-1.546)	0.972	1.082	(0.686-1.705)	0.735	1.072	(0.681-1.688)	0.764
Old	31(29.5)	74(70.5)	0.972	(0.573-1.650)	0.917	1.007	(0.586-1.732)	0.979	1.009	(0.587-1.733)	0.975
Senior	60(31.6)	130(68.4)	1.071	(0.687-1.670)	0.762	1.325	(1.065-1.206)	0.235	1.325	(0.833-2.108)	0.234
Breed	Yes, N (%)	No, N (%)									
Mixed Breed **(Reference)**	49(27.2)	131(72.8)	1.00		0.063	1.00		0.082	1.00		0.080
Labrador Retriever	31(28.7)	77(71.3)	1.076	(0.633-1.830)	0.786	1.188	(0.691-2.042)	0.533	1.182	(0.688-2.031)	0.544
Jack Russell Terrier	25(41.7)	35(58.3)	1.910	(1.038-3.512)	0.037	1.723	(0.923-3.217)	0.088	1.738	(0.931-3.246)	0.083
Cocker Spaniel	23(47.9)	25(52.1)	**2.460**	(1.278-4.733)	**0.007**	**2.710**	(1.383-5.309)	**0.004**	**2.717**	(1.387-5.322)	**0.004**
Border Collie	13(27.7)	34(72.3)	1.022	(0.498-2.097)	0.952	1.069	(0.516-2.215)	0.857	1.063	(0.514-2.202)	0.868
Springer Spaniel	9(25.7)	26(74.3)	0.891	(0.391-2.029)	0.784	0.881	(0.382-2.030)	0.766	0.889	(0.386-2.047)	0.782
Other	104(29.5)	249(70.5)	1.117	(0.748-1.666)	0.589	1.195	(0.793-1.801)	0.395	1.220	(0.797-1.808)	0.382
Sex	Yes, N (%)	No, N (%)									
Male **(Reference)**	140 (34.6)	265 (65.4)	1.00			-	-	-	1.00		
Female	114 (26.7)	313 (73.3)	0.689	(0.513-0.927)	0.014	-	-	-	0.678	(0.500-0.919)	0.12
Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact **(Reference)**	71 (32.6)	147 (67.4)	1.00			-	-	-	1.00		
Neutered	183 (29.8)	431 (70.2)	0.879	(0.631-1.225)	0.447	-	-	-	0.651	(0.656-1.301)	0.924
Sex & Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact Male **(Reference)**	40 (33.3)	80 (66.7)	**1.00**		**0.055**	**1.00**		**0.049**	-	-	-
Male Neutered	100 (35.1)	185 (64.9)	1.081	(0.689-1.697)	0.735	1.486	(0.932-2.370)	0.096	-	-	-
Sexually Intact Female	31 (31.6)	67 (68.4)	0.925	(0.523-1.637)	0.790	**1.641**	(1.149-2.343)	**0.006**	-	-	-
Female Neutered	83 (25.2)	246 (74.8)	0.675	(0.429-1.062)	0.089	1.343	(0.813-2.219)	0.250	-	-	-

Within the digestive multivariable modelling, there was an association between OAD RE used and the presence of digestive issues: the use of the term senior was associated with over 3.5 times (95%CI (2.132-6.564), *P*<0.001) the odds of digestive issues compared with the reference term ageing, elderly was over 2 times the odds (95%CI (1.308-4.238), *P*=0.004, old was over 2 times the odds (95%CI (1.159-4.259), *P*=0.016), and geriatric over 1.5 times the odds (95%CI (1.042-3.326), *P*=0.036) (Table 3.13).

Within the integument multivariable modelling, no significant associations were identified (Table 3.14).

Within the musculoskeletal multivariable modelling (Table 3.15), with every year of age there was a ~8% increase in the odds of musculoskeletal issues (OR=1.081, 95%CI (1.018-1.148), P=0.011). Significant associations were identified between breed and the presence of musculoskeletal issues: for example, Cocker Spaniels had less than half (OR=0.364, 95%CI (0.165-0.807), P=0.013) and Other breeds approximately half (OR=0.607, 95%CI (0.413-0.892), P=0.011) the odds of presenting with musculoskeletal issues compared with Mixed Breeds. There was also an association between sex and neuter status and the odds of musculoskeletal issues, as neutered males were at greater odds (OR=1.988, 95%CI 1.168-3.386, P=0.011) than sexually intact females.

The multivariable analysis suggests an association between OAD RE used and the presence of weight issues (Table 3.16): the use of the term senior was associated with ~3 times (OR=2.903, 95% CI (1.844-4.570), *P*<0.01) the odds of weight issues compared with the reference term ageing.

Table 3.13: Digestive disease. Logistic regression analyses of factors associated with digestive ICD-10 categorisation in the OAD sub-sample

Model 1: N = 832. Hosmer-Lemeshow = 0.856. Adjusted model for age, OAD RE, breed, sex and neuter status.

Model 2: N = 832. Hosmer-Lemeshow = 0.934. Adjusted model for age, OAD RE, breed, sex, and neuter status.

Variable			**Unadjusted**			**Model 1**			**Model 2**		
			OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Age			1.031	(0.971-1.094)	0.316	1.057	(0.989-1.129)	0.102	1.057	(0.989-1.129)	0.102
OAD RE	Yes, N (%)	No, N (%)									
Ageing **(Reference)**	21(11.9)	155(88.1)	**1.00**		**0.000**	**1.00**		**0.000**	**1.00**		**0.000**
Elderly	42(25.6)	122(74.4)	2.541	(1.430-4.516)	**0.001**	**2.354**	(1.308-4.238)	**0.004**	**2.353**	(1.307-4.234)	**0.004**
Geriatric	39(19.8)	158(80.2)	1.822	(1.025-3.237)	**0.041**	**1.862**	(1.042-3.326)	**0.036**	**1.875**	(1.050-3.348)	**0.034**
Old	61(32.1)	129(67.9)	2.187	(1.148-4.166)	**0.017**	**2.222**	(1.159-4.259)	**0.016**	**2.220**	(1.159-4.252)	**0.016**
Senior	24(22.9)	81(77.1)	**3.490**	(2.017-6.038)	**0.000**	**3.741**	(2.132-6.564)	**0.000**	**3.728**	(2.126-6.539)	**0.000**
Breed	Yes, N (%)	No, N (%)									
Mixed Breed **(Reference)**	40(22.2)	140(77.8)	1.00		0.684	1.00		0.773	1.00		0.788
Labrador Retriever	17(15.7)	91(84.3)	0.654	(0.350-1.223)	0.183	0.735	(0.388-1.394)	0.346	0.739	(0.390-1.400)	0.354
Jack Russell Terrier	15(25.0)	45(75.0)	1.167	(0.590-2.307)	0.658	1.174	(0.581-2.370)	0.655	1.163	(0.577-2.346)	0.673
Cocker Spaniel	11(22.9)	37(77.1)	1.041	(0.487-2.223)	0.918	1.159	(0.530-2.538)	0.711	1.161	(0.531-2.540)	0.708
Border Collie	12(25.5)	35(74.5)	1.200	(0.570-2.525)	0.631	1.343	(0.628-2.872)	0.447	1.343	(0.628-2.872)	0.447
Springer Spaniel	7(19.4)	29(80.6)	0.845	(0.344-2.072)	0.713	0.885	(0.354-2.213)	0.793	0.875	(0.350-2.187)	0.775
Other	187(22.5)	645(77.5)	1.110	(0.724-1.703)	0.632	1.159	(0.746-1.802)	0.511	1.150	(0.740-1.786)	0.535
Sex	Yes, N (%)	No, N (%)									
Male **(Reference)**	95 (23.5)	310 (76.5)	1.00			-	-	-	1.00		
Female	92 (21.5)	335 (78.5)	0.896	(0.647-1.241)	0.509	-	-	-	0.847	(0.605-1.185)	0.331
Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact **(Reference)**	41 (18.8)	177 (81.2)	1.00			-	-	-	1.00		
Neutered	146 (23.8)	468 (76.2)	1.347	(0.914-1.984)	0.132	-	-	-	1.323	(0.889-1.968)	0.168
Sex & Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact Male **(Reference)**	26 (21.7)	94 (78.3)	1.00		0.317	1.00		0.315	-	-	-
Male Neutered	69 (24.2)	216 (75.8)	1.155	(0.692-1.927)	0.581	1.091	(0.646-1.844)	0.744	-	-	-
Sexually Intact Female	15 (15.3)	83 (84.7)	0.653	(0.324-1.317)	0.234	0.602	(0.295-1.231)	0.164	-	-	-
Female Neutered	77 (23.4)	252 (76.6)	1.105	(0.668-1.828)	0.698	1.020	(0.608-1.711)	0.940	-	-	-

Table 3.14: Integumentary disease. Logistic regression analyses of factors associated with integument ICD-10 categorisation in the OAD sub-sample

Model 1: N = 832. Hosmer-Lemeshow= 0.531. Adjusted model for age, OAD RE, breed, sex and neuter status.

Model 2: N = 832. Hosmer-Lemeshow = 0.539. Adjusted model for age, OAD RE, breed, sex, and neuter status.

Variable			**Unadjusted**			**Model 1**			**Model 2**		
			OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Age			0.968	(0.917-1.021)	0.233	0.966	(0.910-1.025)	0.249	0.966	(0.910-1.025)	0.247
OAD RE	Yes, N (%)	No, N (%)									
Ageing **(Reference)**	44(25.0)	132(75.0)	1.00		0.345	1.00		0.293	1.00		0.301
Elderly	43(26.2)	121(73.8)	1.066	(0.655-1.736)	0.797	1.100	(0.667-1.815)	0.709	1.100	(0.666-1.814)	0.710
Geriatric	62(31.5)	135(68.5)	1.378	(0.874-2.171)	0.167	1.360	(0.858-2.155)	0.191	1.350	(0.852-2.137)	0.201
Old	36(34.3)	69(65.7)	1.565	(0.923-2.654)	0.096	1.562	(0.916-2.665)	0.102	1.562	(0.916-2.665)	0.102
Senior	50(26.3)	140(73.7)	1.071	(0.670-1.714)	0.773	0.975	(0.602-1.580)	0.918	0.975	(0.602-1.579)	0.917
Breed	Yes, N (%)	No, N (%)									
Mixed Breed **(Reference)**	49(27.2)	131(72.8)	1.00		0.573	1.00		0.574	1.00		0.571
Labrador Retriever	31(28.7)	77(71.3)	1.158	(0.682-1.965)	0.587	1.153	(0.675-1.971)	0.602	1.150	(0.673-1.964)	0.610
Jack Russell Terrier	25(41.7)	35(58.3)	1.087	(0.567-2.086)	0.801	1.160	(0.600-2.242)	0.660	1.170	(0.605-2.260)	0.641
Cocker Spaniel	23(47.9)	25(52.1)	1.021	(0.499-2.093)	0.954	1.032	(0.498-2.137)	0.932	1.035	(0.500-2.143)	0.925
Border Collie	13(27.7)	34(72.3)	0.651	(0.293-1.447)	0.292	0.639	(0.287-1.426)	0.275	0.638	(0.286-1.424)	0.273
Springer Spaniel	9(25.7)	26(74.3)	0.664	(0.273-1.615)	0.366	0.660	(0.269-1.620)	0.364	0.665	(0.271-1.632)	0.373
Other	104(29.5)	249(70.5)	1.228	(0.823-1.833)	0.313	1.220	(0.812-1.834)	0.337	1.224	(0.815-1.839)	0.330
Sex	Yes, N (%)	No, N (%)									
Male **(Reference)**	109 (26.9)	296 (73.1)	1.00			-	-	-	1.00		
Female	126 (29.5)	301 (70.5)	1.137	(0.840-1.538)	0.134	-	-	-	1.121	(0.824-1.525)	0.468
Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact **(Reference)**	53 (24.3)	165 (75.7)	1.00			-	-	-	1.00		
Neutered	182 (29.6)	432 (70.4)	1.312	(0.920-1.870)	0.115	-	-	-	1.336	(0.932-1.915)	0.115
Sex & Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact Male **(Reference)**	26 (21.7)	94(78.3)	1.00		0.359	1.00		0.299	-	-	-
Male Neutered	83 (29.1)	202 (70.9)	1.486	(0.898-2.459)	0.124	1.539	(0.924-2.562)	0.098	-	-	-
Sexually Intact Female	27 (27.6)	71 (72.4)	1.375	(0.739-2.557)	0.315	1.393	(0.745-2.604)	0.299	-	-	-
Female Neutered	99 (30.1)	230 (69.9)	1.556	(0.949-2.551)	0.079	1.610	(0.976-2.655)	0.062	-	-	-

Table 3.15: Musculoskeletal disease. Logistic regression analyses of factors associated with musculoskeletal ICD-10 categorisation in the OAD sub-sample

Model 1: N = 832. Hosmer-Lemeshow = 0.025. Adjusted model for age, OAD RE, breed, sex and neuter status.

Model 2: N = 832. Hosmer-Lemeshow = 0.054. Adjusted model for age, OAD RE, breed, sex, and neuter status.

Variable			Unadjusted			Model 1			Model 2		
			OR	95% CI	p	OR	95% CI	P	OR	95% CI	P
Age			**1.074**	(1.018-1.133)	**0.009**	**1.081**	(1.018-1.148)	**0.011**	**1.081**	(1.018-1.148)	**0.011**
OAD RE	Yes, N (%)	No, N (%)									
Ageing **(Reference)**	52(29.5)	124(70.5)	1.00		0.651	1.00		0.691	1.00		0.682
Elderly	60(36.6)	104(63.4)	1.376	(0.874-2.166)	0.168	1.282	(0.798-2.061)	0.304	1.284	(0.799-2.063)	0.301
Geriatric	70(35.5)	127(64.5)	1.314	(0.850-2.032)	0.219	1.374	(0.878-2.150)	0.164	1.380	(0.882-2.159)	0.158
Old	35(33.3)	70(66.7)	1.192	(0.709-2.004)	0.507	1.189	(0.698-2.025)	0.524	1.186	(0.696-2.020)	0.530
Senior	61(32.1)	130(67.9)	1.128	(0.723-1.759)	0.296	1.309	(0.823-2.081)	0.255	1.308	(0.823-2.078)	0.257
Breed	Yes, N (%)	No, N (%)									
Mixed Breed **(Reference)**	72(40.0)	108(60.0)	**1.00**		**0.002**	**1.00**		**0.002**	**1.00**		**0.002**
Labrador Retriever	48(44.4)	60(55.6)	**1.200**	(0.741-1.944)	0.459	1.288	(0.787-2.108)	0.313	1.291	(0.789-2.112)	0.309
Jack Russell Terrier	17(28.3)	43(71.7)	0.593	(0.314-1.120)	0.107	0.532	(0.278-1.018)	0.057	0.529	(0.276-1.013)	0.055
Cocker Spaniel	9(18.8)	39(81.3)	**0.346**	(0.158-0.758)	**0.008**	**0.364**	(0.165-0.807)	**0.013**	**0.364**	(0.164-0.806)	**0.013**
Border Collie	16(34.0)	31(66.0)	0.774	(0.395-1.518)	0.456	0.800	(0.405-1.580)	0.520	0.801	(0.406-1.583)	0.524
Springer Spaniel	16(44.4)	20(55.6)	1.200	(0.583-2.470)	0.621	1.156	(0.555-2.407)	0.699	1.150	(0.552-2.394)	0.709
Other	100(28.3)	253(71.7)	**0.593**	(0.406-0.865)	**0.007**	**0.607**	(0.413-0.892)	**0.011**	**0.605**	(0.411-0.889)	**0.010**
Sex	Yes, N (%)	No, N (%)									
Male **(Reference)**	150 (37.0)	255 (63.0)	**1.00**			-	-	-	**1.00**		
Female	128 (30.0)	299 (70.0)	**0.728**	(0.545-0.972)	**0.031**	-	-	-	**0.670**	(0.497-0.904)	**0.009**
Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact **(Reference)**	67 (30.7)	151 (69.3)	1.00			-	-	-	1.00		
Neutered	211 (34.4)	403 (65.6)	1.180	(0.846-1.645)	0.329	-	-	-	1.241	(0.880-1.750)	0.217
Sex & Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact Female **(Reference)**	24 (24.5)	74 (75.5)	1.00		0.093	**1.00**		**0.044**	-	-	-
Sexually Intact Male	43 (35.8)	77 (64.2)	1.722	(0.952-3.114)	0.072	1.762	(0.961-3.230)	0.067	-	-	-
Male Neutered	107 (37.5)	178 (62.5)	1.853	(1.103-3.115)	0.020	**1.988**	(1.168-3.386)	**0.011**	-	-	-
Female Neutered	104 (31.6)	225 (68.4)	1.425	(0.851-2.387)	0.178	1.406	(0.831-2.380)	0.204	-	-	-

Table 3.16: Weight issues. Logistic regression analyses of factors associated with weight ICD-10 categorisation in the OAD sub-sample

Model 1: N = 832. Hosmer-Lemeshow = 0.870. Adjusted model for age, OAD RE, breed, sex and neuter status.

Model 2: N = 832. Hosmer-Lemeshow = 0.903. Adjusted model for age, OAD RE, breed, sex, and neuter status.

Variable			**Unadjusted**			**Model 1**			**Model 2**		
			OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Age			**0.909**	(0.863-0.958)	**0.000**	**0.936**	(0.884-0.991)	**0.023**	**0.937**	(0.885-0.991)	**0.024**
OAD RE	Yes, N (%)	No, N (%)									
Ageing **(Reference)**	45(25.6)	131(74.4)	**1.00**		**0.000**	**1.00**		**0.000**	**1.00**		**0.000**
Elderly	49(29.9)	115(70.1)	1.240	(0.771-1.996)	0.375	1.434	(0.878-2.343)	0.150	1.436	(0.879-2.345)	0.148
Geriatric	64(32.5)	133(67.5)	1.401	(0.892-2.200)	0.143	1.396	(0.884-2.206)	0.152	1.415	(0.896-2.233)	0.136
Old	33(31.4)	72(68.6)	1.334	(0.783-2.274)	0.289	1.332	(0.776-2.286)	0.298	1.331	(0.776-2.283)	0.299
Senior	98(51.6)	92(48.4)	**3.101**	(1.993-4.826)	**0.000**	**2.903**	(1.844-4.570)	**0.000**	**2.895**	(1.840-4.555)	**0.00**
Breed	Yes, N (%)	No, N (%)									
Mixed Breed **(Reference)**	65(36.1)	115(63.9)	1.00		0.511	1.00		0.625	1.00		0.594
Labrador Retriever	38(35.2)	70(64.8)	0.960	(0.583-1.581)	0.874	0.964	(0.576-1.611)	0.888	0.970	(0.581-1.619)	0.907
Jack Russell Terrier	16(26.7)	44(73.3)	0.643	(0.337-1.230)	0.182	0.709	(0.364-1.382)	0.313	0.696	(0.357-1.355)	0.287
Cocker Spaniel	22(45.8)	26(54.2)	1.497	(0.786-2.851)	0.220	1.445	(0.740-2.821)	0.281	1.434	(0.736-2.793)	0.290
Border Collie	17(36.2)	30(63.8)	1.003	(0.514-1.956)	0.994	1.043	(0.526-2.069)	0.903	1.043	(0.526-2.069)	0.903
Springer Spaniel	10(27.8)	26(72.2)	0.680	(0.309-1.500)	0.340	0.679	(0.301-1.531)	0.351	0.669	(0.297-1.505)	0.331
Other	121(34.3)	232(65.7)	0.923	(0.634-1.343)	0.675	0.863	(0.585-1.274)	0.459	0.856	(0.580-1.263)	0.433
Sex	Yes, N (%)	No, N (%)									
Male **(Reference)**	135 (66.7)	270 (66.7)	1.00			-	-	-	1.00		
Female	154 (36.1)	273 (63.9)	1.128	(0.848-1.501)	0.408	-	-	-	1.130	(0.840-1.520)	0.418
Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact **(Reference)**	74 (33.9)	144 (66.1)	1.00			-	-	-	1.00		
Neutered	215 (35.0)	399 (65.0)	1.049	(0.757-1.452)	0.775	-	-	-	0.977	(0.697-1.369)	0.893
Sex & Neuter Status	Yes, N (%)	No, N (%)									
Sexually Intact Male **(Reference)**	44 (36.7)	76 (63.3)	1.00		0.364	1.00		0.361	-	-	-
Male Neutered	91 (31.9)	194 (68.1)	0.810	(0.518-1.267)	0.356	0.753	(0.474-1.195)	0.228	-	-	-
Sexually Intact Female	30 (30.6)	68 (69.4)	0.762	(0.432-1.345)	0.348	0.753	(0.420-1.348)	0.339	-	-	-
Female Neutered	124 (37.7)	205 (62.3)	1.045	(0.678-1.611)	0.843	0.982	(0.628-1.538)	0.938	-	-	-

3.3.8 Disease sub-categorisation

As previously mentioned, a consultation may contain multiple issues discussed and recorded when a dog is presented to practice, which were categorised and then further sub-categorised. For example, a dog may be recorded as presenting with more than one dental issue (the major category) which can then be sub-categorised (e.g., halitosis and dental disease). Therefore, in the top level of categorisation this counted as one case of a dental issue, and in the sub-categorisation stage it will count as two independent dental issues.

A total of 2,292 complaints were identified in the free text of these 832 consultations, which after iterative analyses were categorised into 532 sub-categories (see appendices B-T). Each major of the 21 categories had from 1-79 respective sub-categories. Most dogs were recorded as presenting for multiple categories (Table 3.17, median=2, range=0-10).

Table 3.17: Descriptive summary of how many dogs were recorded as presenting with multiple issues (sub-categories) in the OAD sub-sample

Number of issues recorded when presenting to practice	Count N (%)
0	0 (0)
1	188 (22.6)
2	240 (28.8)
3	180 (21.6)
4	111 (13.3)
5	62 (7.5)
6	30 (3.6)
7	13 (1.6)
8	5 (0.6)
9	1 (0.1)
10	1 (0.1)

A summary of the top sub-categories for each over-arching category can be found in Table 3.18, showing the number of dogs affected by at least one sub-category within each category.

*Table 3.18: The top two sub-categories per over-arching category as a result of categorisation of EHRs of the OAD sub-sample, not including the Travel and No features found categories *three sub-categories are included as two are joint second, **only one sub-category present ***Denominator of total complaints (2,292) used to calculate percentage*

Category	Count N (%***)	Sub-Category	Count N (%***)
Auditory	42 (1.8)	Hearing loss	38 (1.7%)
		Causes of hearing loss – discussed	2 (0.09%)
Behaviour*	75 (3.3)	Barking	11 (0.48%)
		Confused	9 (0.39%)
		Unsettled at night	9 (0.39%)
Cardiopulmonary	169 (7.4)	Murmur	57 (2.49%)
		Coughing	42 (1.83%)
Dental	362 (15.8)	Tartar	109 (4.76%)
		Gingivitis	32 (1.40%)
Digestive	230 (10.0)	Vomiting	39 (1.70%)
		Inappetent	32 (1.40%)
Endocrine	8 (0.3)	Hypothyroid	3 (0.13%)
		Insulin - discussion	2 (0.09%)
Euthanised	37 (1.6)	Euthanasia - discussed	19 (0.83%)
		Euthanasia - completed	18 (0.79%)
Immunological	209 (9.1)	Vaccination	66 (2.88%)
		Vaccination - L4	52 (2.27%)
Integument	270 (11.8)	Nail - clipped	28 (1.22%)
		Anal glands	25 (1.09%)
Microchip	24 (1.0)	Microchip - checked	21 (0.92%)
		Microchip - discussed	2 (0.09%)
Musculoskeletal	375 (16.4)	Stiff	60 (2.62%)
		Lameness	52 (2.27%)
Neoplasia	200 (8.7)	Mass/Lumps	30 (1.31%)
		Mass - mammary	11 (0.48%)
Neurological	107 (4.7)	Proprioceptive deficit	23 (1.00%)
		Brain ageing	19 (0.83%)
Ocular	205 (8.9)	Cataracts	53 (2.31%)
		Sclerosis	31 (1.35%)
Other**	1 (0.04)	Unknown	1 (0.04%)
Parasites	14 (0.6)	Fleas	5 (0.22%)
		Discuss anti-parasite treatment	3 (0.13%)
		Dispense anti-parasite treatment	3 (0.13%)
Reproductive	14 (0.6)	Genital check	4 (0.17%)
		Pyometra - discussed	3 (0.13%)
Urinary	129 (5.6)	Incontinence	44 (1.92%)
		Polyuria and polydipsia	31 (1.35%)
Weight	457 (19.9)	Weight loss	93 (4.06%)
		Ideal - BCS recorded	47 (2.05%)

3.3.9 ICD-10 sub-categorisation and age

A breakdown of the most common sub-categories can be found in Table 3.19. The most common sub-categories within the 2,292 complaints were: tartar (109, 4.8%), weight loss (93, 4.1%), and stiffness (60, 2.6%). The median age for each sub-category was: 12.3y (tartar), 13.2y (weight loss), and 12.8y (stiffness). The median ages of the top three sub-categories were not found to be statistically different (*P*=0.163).

*Table 3.19: The most common sub-categories (30+ consultations) as a result of categorisation of EHRs of the OAD sub-sample *Denominator of 2,292 complaints used to calculate percentage*

Category	Count of Category	Sub-category	Count (% of all complaints*)	% of count of category
Dental	362	Tartar	109 (4.8%)	30.1%
Weight	457	Weight loss	93 (4.1%)	20.4%
Immunological	209	Vaccination	66 (2.9%)	31.6%
Musculoskeletal	375	Stiff	60 (2.6%)	16.0%
Cardiopulmonary	169	Murmur	57 (2.5%)	33.7%
Immunological	209	Vaccination - L4	52 (2.3%)	24.9%
Ocular	205	Cataracts	53 (2.3%)	25.9%
Musculoskeletal	375	Lameness	52 (2.3%)	13.9%
Weight	457	Ideal - BCS recorded	47 (2.1%)	10.3%
Urinary	129	Incontinence	44 (1.9%)	34.1%
Cardiopulmonary	169	Coughing	42 (1.8%)	24.9%
Musculoskeletal	375	Loss of muscle mass	40 (1.7%)	10.7%
Weight	457	Diet – discussed	24 (1.0%)	5.3%
Digestive	230	Vomiting	39 (1.7%)	17.0%
Auditory	42	Hearing loss	38 (1.7%)	90.5%
Weight	457	Weight gain	35 (1.5%)	7.7%
Digestive	230	Inappetent	32 (1.4%)	13.9%
Immunological	209	Vaccination – KC	32 (1.4%)	15.3%
Dental	362	Gingivitis	32 (1.4%)	8.8%
Neoplasia	200	Mass/Lumps	30 (1.3%)	15.0%
Urinary	129	Polyuria and polydipsia	31 (1.4%)	24.0%
Ocular	205	Sclerosis	31 (1.4%)	15.1%
Dental	362	Dental disease	30 (1.3%)	8.3%

3.4 Discussion

Identifying the most common issues in OADs may help to focus healthcare messaging to owners regarding appropriate preventive measures, signs to look out for, and effective treatment recommendations. Here, using a new approach based on regular expressions, followed by disease classification adapted from a well-established international human disease system (ICD-10), the top five recorded issues in OADs in this study population were shown to be dental, digestive, integument, musculoskeletal and weight. It was also common for dogs to be recorded as presenting with multiple issues, with dogs most frequently presenting with 2 issues (28.8%).

Dental issues were most common, particularly sub-categories of tartar and gingivitis. In this study prevalence of tartar formation was found to be 13.1% of all 832 consultations, considerably lower than the 61.3% reported in a study of 408 dogs presenting to a private Czech small animal clinic (Kyllar & Witter 2005). However, this latter study was carried out specifically to evaluate the levels of dental disease and so potentially allows for the identification of more cases than would be spotted and recorded during a consultation. Clearly our work relies on veterinarians recording issues, which is likely to only happen when they reach certain thresholds, and also may be less likely to occur where other diseases perceived of greater clinical significance at the time of the consultation were present. The levels of tartar reported here are more broadly in line with those of a larger study of almost 4,000 UK dogs, in which O'Neill et al. (2014) found 9.3% of dogs had recorded periodontal disease somewhere in their patient record, second only to otitis externa as a recorded complaint. However, periodontal disease was only categorised in those patients where a "medical or surgical intervention" was recommended, a higher threshold than used here. Unfortunately, the presenting signs used to classify a case as having periodontal disease in the O'Neill et al. (2014) study were not given making a more detailed comparison to our study difficult. Perhaps not surprisingly, and consistent with earlier work (Kortegaard, Eriksen & Baelum 2008), there was evidence for an

increase of dental issues with age, even with the preselected population of old patients used here, emphasising the importance of tackling this issue to prevent occurrence in old age dogs. By preventing the formation of plaque and tartar, progression to periodontal disease can also be avoided (Harvey, Serfilippi & Barnvos 2015). This may benefit the general health of dogs (Whyte et al. 2014) by preventing systemic disease (Rawlinson et al. 2011) highlighting the importance of oral health. It would be interesting to know whether some veterinarians felt that a level of dental disease was inevitable in old animals and so became less likely to record it – in the next chapter of this thesis, how dental disease is recorded across an animal's life span rather than just in the old age animals used for this study is explored.

The most common digestive issues included sub-categories of vomiting and dogs being inappetent. A reduction in appetite may be defined as hyporexia, whereas a loss of appetite may be defined as anorexia (Delaney 2006). A previous study of 3,864 dogs admitted to a teaching veterinary hospital at Cairo University also found vomiting as the most common digestive issue, with anorexia as the fourth most common digestive issue at 13.6% and 13.1% respectively (Rakha et al. 2015); this compared to the current study in which 1.7% of complaints were vomiting and 1.4% of complaints were inappetence. As well as obvious differences in the geography of the studied population (Egypt vs UK), the higher levels of digestive disease reported in Egypt may be related to differences in case load associated with sampling from a teaching hospital (SAVSNET collects data primarily form first opinion practitioners), and also that the percentages for the Egyptian study excluded consultations with healthy animals.

Integument included a range of issues; the most common sub-categories were dogs needing their nails clipping (1.2% of complaints) or having an issue with their anal glands (1.1% of complaints). A study of 3,884 dogs in the UK of dogs also found these to be some of the most common issues

recorded but with a higher prevalence than the current study, with overgrown nails prevalent at 7.1% and anal sac impaction also at 7.1% (O'Neill et al. 2014). The reasons for the higher levels reported in this latter study are unclear, especially when the two study populations are broadly similar (primary care, electronic health data and similar time scale). However, it is likely that O'Neill et al. (2014) used multiple records for individual dogs describing an animal level of disease; in this study only a single consultation for each aged dog was selected.

Musculoskeletal issues were the second most common disease category reported here, and have been reported as common issues in a previous study at 8.64% (O'Neill et al. 2021). Within this study the common identified sub-categories were dogs feeling stiff or lameness, both of which are signs of osteoarthritis (Johnson, Lee & Swanson 2020; Pettitt & German 2015). Previous studies have found the occurrence of osteoarthritis issues to be at 2.5% in dogs in the UK in 2013 in primary veterinary care (Anderson et al. 2018), in comparison to 2.6% dogs reported as being stiff and 2.3% experiencing lameness in the current study.

Weight was also a common issue recorded; however, rather than the sub-categories commonly including overweight dogs which may have been expected due to previous studies identifying obesity as a common issue in the dog population (Courcier et al. 2010), it was in fact weight loss which was more frequently observed within this category. This may perhaps be because weight loss is an issue which owners may present their old age dogs to practice for rather than weight gain. Weight loss in old age pets with normal intake, or increased intake of a reduce calorie diet may be normal due to high energy needs, alternatively it could be due to malabsorption of nutrients (Laflamme, 2005). This may be unexplained weight loss which requires further investigation (Holt, 2021). For example, an animal which may be ill and losing weight could be due to cachexia, in which amino acids from muscle and lean body mass are catabolised (Freeman, 2012).

Some issues stood out because of how rarely they were mentioned in the clinical narratives used for this study. Parasite problems only made up 0.6% of all recorded issues. This could suggest these are issues which are dealt with adequately at a younger age so as not to become a common issue within the old age dog population. Alternatively, these may be disorders that are considered trivial in the comparison to more seemingly serious disorders seen in these older patients, making them less likely to be recorded.

The distribution of the common issues amongst the common breeds was not found to be significant, apart from a significant association between breed and dental issues, in which the Cocker Spaniel was found to be over 2.5 times more at risk than Mixed Breeds. This potential link of the Cocker Spaniels to dental disease has been observed before; O'Neill et al (2014) also found Cocker Spaniels to be at statistically increased odds of periodontal disease. Gingival hyperplasia which may result in periodontal disease was found to be most common amongst Cocker Spaniels, as well as Collies and Boxers (Holmstrom 2012), and could suggest a mechanism for this observed increased risk. The reasons for this occurrence require further work and understanding; however, even in the absence of such further work, these studies may highlight a population to target in terms of informing owners of Cocker Spaniels so that appropriate preventative measures can be taken at a time to maximise their impact. In addition, there was a significant association between breed and the occurrence of musculoskeletal issues, with Cocker Spaniels at less than half the risk and Other breeds at approximately half the odds than Mixed Breeds. This is somewhat at odds with a previous study, where Labrador Retrievers and Springer Spaniels were found to be at increased risk of osteoarthritis (Anderson et al. 2018).

The age at which the most common issues occurred was found to be significantly different, with dental and musculoskeletal issues occurring later than the other most common issues at 13.0y. For musculoskeletal and dental issues, prevalence (OR) increased with age, consistent with these syndromes being age related, and suggesting both continue to deteriorate in the purposefully selected old cohort of dogs chosen for analysis here. This is a finding that has been reported previously in which the odds of osteoarthritis increased with age (Anderson et al. 2018). This may perhaps indicate that these issues are not being noticed and discussed until a late stage, and emphasises the importance of informing owners of the signs to be aware of. The age at which these common issues occur may also highlight a point prior to which it would be beneficial to implement preventive healthcare strategies.

Breed differences were also found for median age at presentation; the Labrador Retrievers were aged 12.15y, Cocker Spaniels were aged 12.14y, and Jack Russell Terriers were aged 15.09 years when they were presented for musculoskeletal issues. The Labrador Retriever was 12.34y when dental issues were noted, the Cocker Spaniel 12.49y, and the Jack Russell Terrier 14.35y. The Cocker Spaniel was 11.52y, the Labrador Retriever was 12.97y, and the Jack Russell Terrier was 14.35y when they were presented for digestive issues. Ultimately, it might be beneficial to understand why particular breeds seem to present with certain issues sooner than others. By taking a targeted, more personalised approach, rather than treating all breeds the same, these data may be used to apply bespoke preventive medicine to individual breeds and highlight what disease categories to focus on and ideal times to carry out health checks. Overall, this knowledge can be applied to the ageing dog population with the ultimate aim of reducing the prevalence of these common issues.

The literature supports a significant difference between the four sex/neuter status groups for being overweight (Bjørnvad et al. 2019). In contrast, in the current study the occurrence of weight issues

was not found to be significant when compared between sexes and dogs with a different neuter status. This may be explained by the category 'weight' containing a variation of sub-categories within this project. As such, this category did not focus solely on overweight dogs, but also underweight dogs, or those who experience unexplained weight loss. The dogs recorded as presenting within this category are also old-age dogs, rather than capturing a younger population or a population containing a wide age range.

Regarding musculoskeletal issues, males were at increased risk in comparison to females. This supports previous studies, in which males were 1.2 times more likely than females to experience osteoarthritis (Anderson et al. 2018). Males may be more likely to experience osteoarthritis due to sex hormones or bodyweight differences (Hays et al. 2007); however, further studies may provide an explanation for this association.

Limitations encountered at this stage in the project include the use of EHRs. For example, the reading of consultations is time consuming and so, without time constraint, a greater number of consultations could have been analysed. Analyses of these data was also limited to what was written within the EHR. Previous studies have shown that not everything discussed within a consultation may be recorded within the EHR (Jones-Diette et al. 2017). As such, if these data are not recorded, they cannot be analysed and, therefore, the numbers of categories and sub-categories are likely to underestimate the true burden of disease. It seems reasonable also that practitioners may prioritise the recording of certain disease types, perhaps based on severity, or ability to treat, such that the data presented here may be biased towards certain categories or sub-categories, so when taken together, the data presented here may not be fully representative of common issues in OADs.

In addition, the consultations were categorised by the first author. In some cases where a disease category or sub-category was not clear, assistance was required by an experienced researcher and veterinarian. Whilst efforts were made to ensure accurate categorisation, there may be instances of inaccuracies in the occurrence of common issues as presented within the findings. In a future study, it may be beneficial for all categorisations to be reviewed by an additional researcher. Some categorisations could have also been explored further, by sub-categorising more specifically. For example, dental grading was observed within the written free text of the EHRs but was not categorised due to variation in grading techniques between attending practitioners. This could be explored further in future work in order to provide a deeper insight into the severity, and perhaps progression, of dental issues which are observed and recorded in these populations. As previously mentioned, dogs may have been recorded as presenting with more than one issue. However, there may also be more than one way of sub-categorising an issue a dog has presented with. For example, an obese dog may have a BCS of 9/9. This would be identified as two separate sub-categories ('Obese' and 'BCS 9/9'), suggesting two weight issues for this dog, even though both sub-categories are in fact identifying and describing the same issue in that particular dog. As a result, this may suggest some dogs have more than one problem as multiple ways have been used to describe their issue. To address this, for data analysis purposes, a binary outcome yes/no was modelled for each condition per dog, rather than the number of times the condition was present in the data. Furthermore, some clinical signs could be assigned to multiple potential categories e.g. vomiting which has many potential causes including those outside the category chosen for it, namely digestive. Pragmatically each clinical sign could only be assigned to a single category and the most likely was chosen by the author based on its context in the EHR.

In summary, a novel approach was taken based on regular expressions to identify consultations with old animals, and a semi-quantitative iterative approach, based on the recorded language of the attending practitioner, to better understand the wide range of diseases and syndromes seen in older

age dogs. Such studies are a prerequisite to efficiently target early personalised interventions at the most efficient stage of an individual animal's life span.

Chapter Four: A case control study of risk factors for veterinary presentation of plaque and tartar/calculus in dogs and management/treatment recommendations given

4.1 Introduction

Finally, upon completion of the analyses within Chapters two and three, a common issue in OADs was selected for further investigation, to identify dog types which are more at risk, and to analyse preventive healthcare and treatment advice being offered, in order to identify whether there are any gaps in the way this issue is being tackled. For the purpose of this project, dental issues were chosen, specifically plaque and tartar/calculus (PTC). Dental issues were prioritised for investigation within this chapter both because they were one of the most common conditions recorded in the clinical narratives of health records from OADs (chapter three), and also because of their relative treatability, i.e. whether tackling an issue could be approached by implementing preventive healthcare.

Plaque coats teeth which mineralises and becomes calculus (tartar) which may lead to periodontal disease (Gawor et al. 2018; Harvey 1998). The prevalence of dental issues such as calculus in dogs is reported as 20.5%, gingivitis at 19.5% (Lund et al. 1999), and periodontal disease as 9.3% (O'Neill et al. 2014) making it the most common issue reported in a previous study (Lund et al. 1999). The severity of the issue has also been shown to increase with age (Wallis et al. 2021) (and Chapter three). Different dog types are affected differently, with smaller dogs experiencing increased risk of periodontal disease compared to larger dogs (Wallis et al. 2021). Dental issues are also under-diagnosed meaning they frequently go untreated (Niemiec et al. 2020); however, they are largely preventable with methods such as toothbrushing (Harvey, Serfilippi & Barnvos 2015). Dental issues may also lead to other health issues, such as systemic disease when bacteria enters the blood (Rawlinson et al. 2011). As such, it is crucial to ensure owners of dog types at increased risk are

aware of preventive methods at the right time, and know the signs to look out for so that they present their dogs to practice if there is a problem.

The aim of this study was to understand which dog types are most at risk of developing PTC, facilitating targeted health messaging to inform owners, and prevent PTC occurring as a common issue in OADs. It also aimed to understand what methods of preventive healthcare for PTC are being recommended and implemented. These findings can then be used to address any gaps in this communication, whether it be regarding owner uptake and compliance of advice, or a need for a greater range of suitable preventive measures and effective treatment options.

4.2 Methods

4.2.1 Regular expression development

A regular expression was developed iteratively to extract relevant EHRs relating to the selected dental sub-categories of plaque, tartar, and calculus. Examples of the text to determine the allocation to the corresponding sub-category can be seen in Table 4.1.

*Table 4.1: Examples of text used to determine the allocation to the corresponding Dental sub-category. Text is reproduced verbatim with occasional spelling mistakes. *dental scoring system*

Sub-Category	Text
Plaque	Moderate plaque build up over teeth.
	Teeth good for age mild plaque
	Teeth plaque and C1G1* tartar building up again on remaining teeth, some halitosis
	dental plaque but no sore gums or dental issues
Tartar	Mild tartar reforming dental few years ago.
	tartar. Dental care advised: brush teeth
	tartar build up over upper canines and molars, advised tooth brushing / book in for dental before reaching older age.
	marked tartar and periodontal disease advise GA dental but obviously risk.
Calculus	mod staining mild calculous.
	Some calculus on teeth but gingiva healthy.
	Teeth – significant build up of calculus on all teeth with some gingivitis.
	poor teeth with calculus.

As in Chapter two, the regular expression was again designed to exclude any common negations which would otherwise retrieve clinical consultation notes that were not relevant to the study. Suggested common spelling variations were also included in the regular expression using the Datalab application to ensure a large relevant dataset was captured. The regular expression developed can be found in Table 4.2.

Table 4.2: Regular expression developed to extract EHRs of dogs recorded as having plaque, tartar, or calculus

Word	Regular Expression
Plaque, tartar, and calculus	(?<!no\s)(?<!no\sobvious\s)(?<!no\sdata\son\s)(?<!eosinophilic\s)(?<!eosinophillic\s)(?<!eosinofilic\s)(?<!nasal\s)(?<!nsala\s)(?<!inflammatory)(?<!m[ea])(?<!s)(t[rta]{3}[arue][trea]|t[aty][era][rat][tay][atr][raet]|tar\star|tarar|tartr|tarta|tarat|tatar|trtar|p[al]{2}[qu]{2}e|plaue|plaqye|plque|placque|plauque|cal[acu][clu][ul][lco]us|calculus|calculs|calulus|calclus|caculus|claculus|caluclus|calcuus)(?!-?\s?off)

Using this combination of capture terms ensured an appropriate range of words used to describe the specific dental issues that were chosen for further investigation were incorporated to form a diverse sample of dogs, their associated dental issues and treatments. Accuracy of each word (plaque, tartar, and calculus) in returning relevant consultations was then determined by reviewing notes from 100 consultations found by the regex for each word (therefore 300 consultations in total), and deciding whether each case met the case definition (veterinary-recorded dental disease seen in the consultation). This was completed using the secure database of Datalab followed by Microsoft Excel encrypted documents, whilst ensuring identifiers were removed. Examples of text which indicated whether a record detected by the regular expression was accurate or not can be found in Table 4.3.

Table 4.3: Examples of text to indicate a record detected by the PTC regular expression. Text is reproduced verbatim with occasional spelling mistakes.

Search word	Accurate matches	Inaccurate (false positive) matches
Plaque	Tartar and plaque build up – dental recommended	Possible eosinopillic plaque
	some plaque on teeth	No pain over sinuses, no0 nsala plaques
	teeth bit of plaque but gums ok	Again no duischarge, plaques etc so less likely
	Plaque and gingivitis on teeth	Casket, o will organise own plaque
Tartar	small amount of tartar	no tartar
	V minor dental tartar	
	tartar building up	
	More tartar particularly on carnassials than would expect for dog of his age	
Calculus	100% calculus coverage upon molar teeth	no calculus
	mild calculus	
	Moderate calculus & gingivitis upper molars.	
	heavy dental calculus esp maxillary carnassial teeth	
		no data on calculus yet

4.2.2 Case-control study

A case-control study was then conducted to identify risk factors for PTC issues. The regular expression-identified cases which were then filtered to remove any incomplete and irrelevant records in the following order: practice ID, species, breed, sex, neuter status, insurance status, consult date, and age at consultation. One million random consultations which did not meet the regular expression were then extracted as controls, and a similar process was conducted to remove any incomplete records. The cases and controls were then combined; if consultations from an individual dog were present in both cases and controls (based on unique animal ID), then one of these consultations was deleted at random using a random number generator (Microsoft Excel).

4.2.3 Investigating the most common issues when presenting to practice with plaque, tartar or calculus: treatment and preventive healthcare

A random sub-sample of the free text from 100 case consultations was semi-qualitatively analysed in an inductive method to summarise and describe the conversation within the clinical health narrative on both preventive healthcare and treatment recommendations for PTC issues. This was achieved by inductively creating categories through content analysis of the free text written within EHRs as opposed to using pre-defined categories such as ICD-10 as per previous chapters. Due to time constraints 100 consultations were an appropriate sample size to be read by the researcher. These records were read by the first author to determine whether dental issues were the main reason for presentation, and then categorised based on the discussion surrounding this issue as follows: advice offered, treatment given, or no discussion on dental care recorded. This was achieved by identifying similar advice or treatments which were grouped to iteratively create new codes, for example advising toothbrushing, or treatment of a dental procedure. This method was completed by containing the free text within Datalab, and codes were recorded within Microsoft Excel.

4.3 Statistical Analysis

The association between the continuous outcome of age and the outcome of case and control was assessed with Kruskal-Wallis tests, with post hoc comparisons conducted using Dunn's tests. In addition, the associations between the outcome of case and control and categorical variables (e.g., breed, sex and neuter status, insurance status, and case-control) were assessed using Chi-squared tests and binary logistic regression. Within the logistic regression, Mixed Breed, sexually intact males, and uninsured were used as the reference categories. Multivariable binary logistic regression was used to determine associations between the presence of dental disease and the variables of age, breed, sex, neuter status and insurance status. Modelling consisted of Model 1 (sex and neuter status combined to form four "sexes") to account for differences in sex and neuter status and how

they interact. All univariables were included in the model as they were all important to adjust for, not only to check they were not confounding but also because they were all significant. A probability of $P \leq 0.05$ (two-sided) was used to indicate whether or not there was a statistical significance in these findings. Analyses were conducted in SPSS (SPSS version 26.0, IBM Corp.).

4.4 Results

4.4.1 Case-control Study

Upon development of the regular expression, the approximate accuracy of each word was as follows; plaque (92%), tartar (94%), and calculus (92%). Overall, the accuracy of the final combined regular expression was estimated to be 99%, and the number of matches was 506,234 consultations. In contrast to chapter three, where consultations were read to ensure accuracy, the accuracy of the developed regex here was deemed high enough such that all consultations found by the regex could be taken forward for further analyses.

Approximately 128 records were removed because of missing data, 178,597 were removed because they were species other than dog, 14,557 were removed due to missing breed data, two were removed for inaccurately recording as a dog being less than 0y and 1,652 records were removed due to a dog being >30y (dogs <30y included, given that the world record of the oldest dog was 29y (Guinness, n.d.). Finally, approximately 91,960 records were removed because they were duplicate records (where the dog presented more than once for dental issues), ensuring that only the first occurrence of a dog being recorded with a dental issue was kept for case-control analysis. Of the 311,298 dog consultations which were identified, 219,338 unique dogs were predicted to be involved and affected by dental issues, with some being seen on multiple occasions. Overall, 286,896 records were excluded, with a total of 219,338 unique dogs remaining for analysis. One million random consultations which did not meet the regular expression were then extracted as controls, and a similar process was conducted to remove any incomplete or irrelevant records. As a result, approximately 430 records were removed due to missing data, 250,070 records were removed

because they were the wrong species, 93,603 records were removed due to missing breed data, three records were removed for inaccurately recording a dog being <0y and 4,382 records were removed due to a dog being >30y. Finally, approximately 212,508 records were removed due to being duplicate dogs. Overall, 560,966 consultations were excluded, and 439,004 remained.

The median age of the case population was 7.3y (range 0-24.48y), and comprised 82,747 neutered females (37.7%), 26,736 sexually-intact females (12.2%), 76,113 neutered males (34.7%), and 33, 742 sexually-intact males (15.4%). The most common breeds included Mixed Breed, Cocker Spaniel, and Jack Russell Terrier. The median age of the control population (438,004) was 6.0y (range 0-28.36y), and comprised 135,489 neutered females (30.9%), 78,809 sexually intact females (18%), 132,763 neutered males (30.2%), and 91,943 sexually intact males (20.9%), with the most common breeds including, Mixed Breed, Labrador Retriever, and Cocker Spaniel.

The cases and controls were then combined, and any duplicate dogs were identified and deleted at random using a random number generator (Microsoft Excel). As a result, 91,463 duplicates (45,757 cases and 45,706 controls) were removed, leaving 566,879 unique EHRs available for analysis (173,581 cases and 393,298 controls).

4.4.2 Univariable analyses

4.4.2.1 Age

Univariable analysis revealed evidence of an association between age and case or control status, with a ~10% increase in the odds of being recorded as a case with every year of age (OR=1.120, 95% CI 1.118-1.121, P=0.000; refer to table 4.4 below).

4.4.2.2 Breed

Univariable analysis revealed evidence of an association between breed and case or control status, for example the Labrador Retriever was half the odds of being recorded as a case when compared to the Mixed Breed (OR=0.599, 95% CI=0.584-0.586, P=0.000), whereas the Yorkshire Terrier was at 1.5 times increased odds of being recorded as a case when compared to the Mixed Breed (OR=1.694, 95% CI 1.232-1.296, P=0.000; refer to table 4.4 below).

4.4.2.3 Sex and neuter status

From the univariable analysis there was evidence of an association between sex/neuter status and case or control status, as neutered males (OR=1.294, 95% CI 1.273-1.315, P=0.000) and neutered females were at increased odds of being recorded as a case in comparison to sexually intact males (OR=1.102, 95% CI 1.084-1.120, P=0.000; refer to table 4.4 below).

4.4.2.4 Insurance status

From the univariable analysis there was evidence of an association between insurance status and case or control status, as animals which are recorded as being insured are of increased odds to be recorded as a case (OR=1.122, 95% CI 1.108-1.136, P=0.000; refer to table 4.4 below).

4.4.3 Multivariable modelling

Results from the multivariable modelling showed that with every year of age, there was a ~10% increase in the odds of PTC issues being recorded in the EHR (OR=1.124, 95%CI (1.122-1.125), P<0.01). Significant associations were identified between breed and the presence of recorded PTC: for example, Yorkshire Terriers and Cocker Spaniels had 1.5 times (95% CI 1.520-1.636) and 1.3 times (95% CI 1.308-1.377) the odds of dental issues, compared with the reference Mixed Breed dogs (Table 4.4). Other breeds with albeit more modest increases in the odds of dental issues included

Jack Russell Terriers (OR=1.034, 95%CI (1.007-1.061), *P*=0.014), Springer Spaniels (OR=1.083, 95%CI (1.045-1.122), *P*<0.01), and Cockapoos (OR=1.247, 95%CI 1.200-1.296, *P*<0.01), whereas Border Collies (OR=0.747, 95%CI (0.722-0.773), *P*<0.01), Labrador Retrievers (OR=0.581, 95%CI (0.567-0.596), *P*<0.01), Staffordshire Bull Terriers (OR=0.501, 95%CI (0.483-0.520), *P*<0.01), Shih Tzus (OR=0.874, 95%CI (0.840-0.909), *P*<0.01) and West Highland White Terriers (OR=0.933, 95%CI (0.898-0.969), *P*<0.01) had decreased odds of PTC issues compared to Mixed Breeds (Table 4.4). Furthermore, there was a positive association between neuter status and the odds of PTC issues, with neutered males (OR=1.348, 95%CI (1.325-1.371), *P*<0.01) and neutered females (OR=1.212, 95%CI (1.192-1.233), *P*<0.01) at greater odds than sexually intact males. Finally, a dog recorded as having insurance was associated with modest increased odds of having recorded PTC issues (OR=1.041, 95%CI (1.028-1.055), *P*<0.01).

Table 4.4: Multivariable model incorporating age, breeds, sex and neuter status, and insurance status for dogs recorded as having a dental issue in the case control study.

Model 1: N = 566, 879. Hosmer Lemeshow = 0.000. Adjusted model for age, breed, sex and neuter status, and insurance status.

Variable			Unadjusted			Model		
			OR	95% CI	P	OR	95% CI	P
Age			**1.120**	(1.118-1.121)	**0.000**	**1.124**	(1.122-1.125)	**0.000**
Breed	**Case, N (%)**	**Control, N (%)**						
Mixed Breed (128,257) (Reference)	41,594 (32)	86,663 (68)	**1.00**			**1.000**		
Yorkshire Terrier (13,840)	6,207 (45)	7,633 (55)	**1.694**	(1.635-1.755)	**0.000**	**1.577**	1.520-1.636	**0.000**
Jack Russell Terrier (32,134)	12,130 (38)	20,004 (62)	**1.263**	(1.232-1.296)	**0.000**	**1.034**	1.007-1.061	**0.014**
Cocker Spaniel (33,759)	12,559 (37)	21,200 (63)	**1.234**	(1.204-1.266)	**0.000**	**1.342**	1.308-1.377	**0.000**
West Highland White Terrier (13,492)	4,939 (37)	8,553 (63)	**1.203**	(1.160-1.248)	**0.000**	**0.933**	0.898-0.969	**0.000**
Springer Spaniel (16,154)	5,825 (36)	10,329 (64)	**1.175**	(1.136-1.216)	**0.000**	**1.083**	1.045-1.122	**0.000**
Other (210,139)	61,011 (35)	149,128 (71)	**0.852**	(0.840-0.865)	**0.000**	**0.908**	0.894-0.922	**0.000**
Border Collie (19,636)	5,584 (28)	14,052 (72)	**0.828**	(0.801-0.856)	**0.000**	**0.747**	0.722-0.773	**0.000**
Shih Tzu (14,493)	4,126 (28.5)	10,367 (71.5)	**0.829**	(0.798-0.861)	**0.000**	**0.874**	0.840-0.909	**0.000**
Cockapoo (14,899)	4,164 (28)	10,735 (72)	**0.808**	(0.778-0.839)	**0.000**	**1.247**	1.200-1.296	**0.000**
Labrador (49,945)	11,147 (22)	38,798 (78)	**0.599**	(0.584-0.613)	**0.000**	**0.581**	0.567-0.596	**0.000**
Staffordshire Bull Terrier (20,131)	4,295 (21)	15,836 (79)	**0.565**	(0.545-0.586)	**0.000**	**0.501**	0.483-0.520	**0.000**
Sex & Neuter Status								
Sexually Intact Male (Reference)	31,674 (28)	81,324 (72)	**1.00**			**1.000**		
Male Neutered	58,764 (33.5)	116,594 (66.5)	**1.294**	(1.273-1.315)	**0.000**	**1.348**	(1.325-1.371)	**0.000**
Sexually Intact Female	28,626 (29.5)	68,370 (70.5)	**1.075**	(1.055-1.096)	**0.000**	**1.194**	(1.171-1.218)	**0.000**
Female Neutered	54,517 (30)	127,010 (70)	**1.102**	(1.084-1.120)	**0.000**	**1.212**	(1.192-1.233)	**0.000**
Insurance								
Uninsured (Reference)	117,609 (29.9)	276,149 (70.1)	**1.00**			**1.000**		
Insured	55,972 (32.3)	117,149 (67.7)	**1.122**	(1.108-1.136)	**0.000**	**1.041**	(1.028-1.055)	**0.000**

4.4.4 Investigating most common issues when presenting to practice: treatment and preventive healthcare

Qualitative analysis was completed by reading 100 consultations. In doing so, it was possible to determine whether a consultation truly described a dog with a PTC issue. The number of accurate clinical consultation notes overall was 99 (the false positive was actually describing plaque in the ear which had been detected by the regular expression). The most common reasons for dogs presenting for the consultation in which a PTC issue was recorded included general health checks and vaccination appointments (table 4.5). In 52 dogs (53%), there were 2 reasons, whilst there was only one reason in the remaining 47 cases (47%). Overall, 98 dogs (99%) that were recorded as having PTC were recorded with an issue other than dental health (data not presented).

Table 4.5: Reason for presentation of dogs recorded with PTC issues when investigating advice or treatment offered in a sample of 99 dogs

Reason for presentation recorded	Count
General health check	73
Vaccination	56
Integument	6
Neoplasia	4
Digestive	2
Ocular	2
Behaviour	1
Dental	1
Medication	1
Neurological	1
Other	1
Parasites	1
Urinary	1

The details of different options of treatment or advice relating to the PCT and recorded in the health narrative are summarised in Table 4.6. Four cases were offered both advice and treatment within the consultation in which a PTC issue was discussed, whilst 13 cases also received up to four pieces of advice, and 1 case received 2 treatments; as such, the total number of pieces of advice offered or treatment (112) given is greater than the total number of cases (99). In 54 consultations (55% of 99 consultations), there was no recorded advice or treatment within the EHR. In 11 of the 99 consultations (11%) in which treatment was given, brushing was most common (5). Advice was recorded in 38 of the 99 consultations (38%), which was split into preventive advice (18 of the 99 consultations (18%)), and treatment advice (24 of the 99 consultations, (24%)). Furthermore, the most common treatment advice being a dental procedure (including dental, scale and polish, and extraction) (26), followed by preventive advice to implement tooth brushing (13).

*Table 4.6: Advice or treatment offered in 99 random consultations of dogs recorded as having a plaque, tartar or calculus issue *denominator of 99 consultations used*

Discussion	Count (%*)
Advice	38 (38)
Advice - Preventive	18 (18)
Dental care product	3 (3)
Component in diet	3 (3)
Tooth brushing	13 (13)
Advice - Treatment	24 (24)
Monitor	5 (5)
Extraction	6 (6)
Scale and polish	6 (6)
Dental	14 (14)
Treatment	11 (11)
Dental	2 (2)
Scale and polish	2 (2)
Dental care product	3 (3)
Tooth brushing	5 (5)
No evidence of advice or treatment offered	54 (55)

4.5 Discussion

Work in Chapter three of this thesis highlighted that dental issues, particular plaque, tartar / calculus (PTC), were amongst the most common recorded issues in dogs presenting during old age. The primary aim of this analysis was to understand which dog types were at increased risk of PCT. These data were used to gain some indication of the prevalence of PTC issues, as well as exploring the recorded discussions being had around preventive healthcare and treatment advice. Within the case control study, the risk of PTC issues increased by 10% with every year of age, and neutered and female dogs were at increased odds compared to entire males. The identified risk factors within these data could be used to implement preventive healthcare for those most at risk, enable dental issues to be identified at an earlier stage, and to delay the progression of PTC issues.

These findings on breed were broadly similar to those of others. It was found that Yorkshire Terriers and Cocker Spaniels were at greatest significant odds of having recorded dental issues in this population compared with Mixed Breed dogs, whereas odds were less for Staffordshire Bull Terriers, Border Collies, Labrador Retrievers in addition to some other breeds. Previous studies found an increased likelihood of dental disease in small breeds (Harvey 1998). Possible reasons for this include breed size and skull morphology; for example, brachycephalic breeds may be at risk due to malocclusion and teeth crowding (Bringel et al. 2020; Harvey 1998; Stella, Bauer & Croney 2018). Similarly, in a more recent study which used a similar data set of health records but relied on reading a random 22,000 canine health narratives, it was again found that small breeds such as the Yorkshire and Jack Russell Terriers, were at increased odds of periodontal disease, in addition to the Cocker Spaniel, whereas Labrador Retrievers and Staffordshire Bull Terriers were at decreased odds (O'Neill et al. 2021). Whilst there is broad agreement between these studies, there were some differences with West Highland White Terriers being at reduced odds in the final model in our study but at increased odds in the O'Neill et al. study (2021). The fact that the odds for West Highland White

Terriers moved from increased in our univariable analysis to being reduced in the final model suggests other factors such as age may be more important in this breed, rather than being at increased risk per se. There was a similar downwards trend in odds from univariable to multivariable analysis for the Jack Russell Terrier, again a notoriously long-lived breed, and an upward trend for the Cockapoo, a relatively young type of dog which went from reduced odds in the univariable analysis to increased odds in the multivariable analysis, possibly suggesting this is a type of dog to watch in the future as its members age. The reasons for these discrepancies may reflect inherent differences in these two study designs. Indeed, the O'Neill et al. study (2021), which, as it was based on reading consultations reached an impressive but inevitably smaller overall sample size, did not include age in the analysis of breed risk. In contrast, our methodology was built on a highly accurate regex allowing for very large sample sizes and therefore more complex modelling. This may also explain differences between breed risk in our study and that of Summers et al. (2019), which was based on just 250 cases of dental disease, and which suggested that Greyhounds, Cavalier King Charles Spaniels and Border Terriers were at greatest odds of a dental disorder (Summers et al. 2019). By understanding the factors which lead to increased risk in specific breeds, encouraging breeders to select lower risk individuals for breeding can be advocated for in order to remove these factors and ensure a healthier population.

Neutering was also associated with an increased odds of PTC issues, with neutered males having greatest odds, whilst sexually-intact females had a greater odds than sexually-intact males; this is broadly in line with a previous study (O'Neill et al. 2021). Although the reasons for such an association were unknown, it might be behavioural or hormonal in origin; however, further work would be needed to establish the exact cause. In addition, this may not be a risk factor, but rather a confounding factor for veterinary treatment. Indeed, although our models attempt to control for age, the neuter status of a dog is clearly dependent on age, with all animals being born entire, and a

high proportion progressing to being neutered at various time points throughout life (O'Neill et al. 2021).

The risk of periodontal disease increases with age (Stella, Bauer & Croney 2018), and the same trend was seen in the current data, with an approximately 10% increased odds of PTC issues for every year of age. This emphasises the importance of regular dental check-ups with a veterinarian, and the need for conversations to remind owners of the signs to look out for, and dental care and hygiene to maintain an optimal level of dental health.

A previous study also found insured dogs had 1.3 times increased odds of periodontal disease when compared with uninsured dogs (O'Neill et al. 2021). The apparent increased risk of dental issues in insured dogs could be a result of a bias from a veterinarian perspective (McKenzie 2014). For example, an insured dog may be more likely to attend wellness visits, and as a result dental issues are more likely to be detected and / or recorded. In addition, the cost of care and treatment for PTC issues may not be a barrier for an insured dog, as a result, the dog may be more likely to be recorded as having a dental issue. Further work investigating the increased risk in insured dogs is needed to establish evidence for this.

The aim of the qualitative analysis was to identify signs that could be used to alert owners to the presence of common PTC issues, as well as guiding discussions between veterinarians and owners. Almost all (99%) of dogs recorded as having a PTC issue presented with additional reasons not specific to dental health, and the PTC issue was still observed during the consultation. This may suggest that veterinarians are actively and routinely checking the dental health of a dog during a consultation, despite presenting for a different reason. However, upon reading these consultations,

more than half of the dogs recorded as having a PTC issue had no evidence of advice or treatment recommendations recorded within the EHR. It may be that veterinarians are observing PTC issues, but are not having a discussion with the owner about the issue and what they can do to minimise the effects on their pet's health and wellbeing. Veterinarians may identify the issue, but advice may not be pursued. Perhaps as the dog was presented with other issues there is not enough time in consult to discuss and educate owners around intervention (Belshaw et al. 2018a). Alternatively, of course, advice or treatment might have been verbally discussed within the consultation, but not written records made. The latter possibility is problematic because an EHR is a legal document and requirement (RCVS 2020); if there is no written record then there is no proof of the recommendations made by the attending veterinarian. Further studies are needed to investigate why such discussions are not occurring during consultations or, if they are, why the details are not being formally recorded. Although veterinarians are observing and recording the issue, in order to tackle PTC issues, it is paramount that veterinarians first engage with owners by starting the conversation around preventive measures, signs to look out for, and subsequently treatment options should the issue occur.

That said, advice was recorded during the consultation in 38% of dogs where a PTC issue was identified, with the most common advice being to recommend a dental procedure. This implies that the tartar had progressed to the point where preventive measures (such as tooth brushing) would not be sufficient. The next most common advice was to implement tooth brushing, which may be viewed as a preventive measure and may even reverse the effects of some dental issues (Harvey, Serfilippi & Barnvos 2015). As well as maintaining the dental health and overall welfare of pet dogs, tooth brushing might also reduce veterinary costs for owners (Enlund et al. 2020a). Other preventive measures included adding components within the diet (e.g., carrots or therapeutic diets) or using teeth cleaning products (e.g., toothpaste, antibacterial gel, water additives, and dietary

supplements). However, only 11% of dogs were recorded as receiving treatment for the dental issue; this suggests that the PTC issues were not perceived to be severe enough to warrant treatment. However, the reasons for this may be further explored in future work.

Within this stage of the project, there were limitations on the scope of the qualitative analysis due to time constraints. Further reading of a greater number of consultations and consequent content analysis may have provided a greater insight on the recorded discussions being had between veterinarians and owners regarding dental treatments. Conducting additional qualitative analysis could include surveying veterinarians to understand why they offer certain treatments, or surveying owners to understand what preventive measures would be practical / desirable for them to implement in everyday routines, or treatment options which would be preferred. By understanding these perceptions and attitudes, suitable prevention and treatment can be recommended to tackle dental issues and reduce prevalence. The scope of the project was also limited in understanding why particular dog types were found to have increased odds of tartar, such as breed or insurance status. Future work using alternative sources of data might also help provide a greater insight into the reasons for the current findings. This, in turn might enable preventive healthcare approaches to be better targeted to dogs most at risk from tartar and associated dental issues.

Another limitation to once again consider when designing the regular expression for this stage of the project is that some spelling variations may lower the accuracy, due to their presence within other irrelevant words. For example, ‘ttr’ may be used as an abbreviation for tartar, but is also found within words such as ‘attributed’. Therefore, this variation of tartar was not used and so those consultations were not included in the data analyses presented here. Whilst this data would have been excluded, these types of spelling variations are rare in comparison to others and so it was still possible to extract a large dataset of relevant information.

Dental disease is also a common issue in cats, and similar advice is offered to cat owners, for example, preventive measures such as tooth brushing. However, previous studies have shown that two out of three cat owners are aware of the signs to look out for regarding dental issues (Oskarsson, Axelsson Puurtinen & Penell 2021). Whilst cat owners are aware of dental issues and preventive measures, similar to that observed in dog owners, an increase in the application of preventive healthcare for dental issues is also needed. However, a suitable alternative to toothbrushing is required due to difficulties associated with compliance in owners and tolerance in cats (Oskarsson, Axelsson Puurtinen & Penell 2021).

In conclusion, with the risk of PTC issues increasing with each year of age, it is important to tackle the issue in the interests of the ageing pet dog population, and target health messaging towards the Yorkshire Terriers, Cocker Spaniels, and neutered male which are at increased risk. Overall, it would appear that there is a need for veterinarians to discuss dental issues with owners and what they can do to maintain their pet's dental health. These findings can then ultimately be used to target owners of these dog types in providing appropriate healthcare advice and treatment recommendations, in efforts to reduce the occurrence of these PTC issues in old age dogs to maintain optimal health and welfare.

Chapter Five: Discussion

5.1 Summary of findings

By exploring the growing potential of the use of electronic health records, this thesis aimed to: 1) use a novel data science approach to describe when veterinarians consider a dog to have reached old age; 2) identify the most common complaints discussed in old age consultations, and factors associated with these, and; 3) investigate the most common complaint discussed in a sub-sample of OAD consultations to identify risk factors and explore current healthcare recommendations.

5.1.1 Findings on when veterinarians consider a dog to have reached old age

In Chapter two, consultations involving 'old age' dogs were selected using searches for the OAD RE senior, old, elderly, ageing and geriatric.

Previous studies have taken various approaches to define a dog as old, for example, a blanket definition of 7+ years (Fortney 2012). However, our findings showed that 5% of dogs were defined by a veterinarian as having reached old age by 5y. This was, therefore, not the expected outcome based on the definitions in the literature, and suggests that the definition of this life stage may require further consideration.

The words used to identify old age pets varied in their use by veterinarians. Veterinarians began to describe dogs in this life stage as 'senior' with a median age of 10.7y, in contrast to the word 'elderly' to describe those at a later stage of their lifespan, with a median age of 14.0y. Breeds in the sample of 'old age' dogs also varied by age, suggesting that breeds age differently. In addition, the prevalence of the use of the words by veterinarians to identify old age pets could have been partly

driven by reference to products rather than simply using a word in a sentence because it feels right, for example senior diets, or geriatric blood profiles. As such, this could explain some of the distribution in the median age of words.

5.1.2 Findings on the most common complaints discussed in old age consultations

This study looked at common issues in OADs using data over a six-year time frame, and investigated any effects of breed in addition to age, sex, and neuter status. This provides further insight in comparison to previous studies; for example, one study used data over a one-year period and investigated the effects of age, sex, and neuter status on common disorders in dogs (O'Neill et al. 2021). In Chapter three, common issues in the EHRs of consultations with OADs were identified as being mostly weight, musculoskeletal, dental, integument and digestive issues. Common issues differed in the median age of onset, with dental and musculoskeletal issues being observed and recorded later than weight, integument, and digestive issues at 13.0y. There was an observed significant association between the five most common breeds and occurrence of dental issues. Cocker Spaniels were over 2.5 times more likely to be recorded as having a dental issue than Mixed Breeds. Breed also influenced the onset of issues, with Labrador Retrievers and Cocker Spaniels getting dental and musculoskeletal issues earlier, and Jack Russells being recorded with these issues later. Whether this is simply due to the overall longevity of these breeds, for example as observed in Chapter two or in a previous study in which Jack Russells were shown to have longer life expectancy at 12.72y (Teng et al., 2022), or some other biological effect is unknown. This highlights key issues to look out for in these breeds, and targets for improved health provision for dogs, and perhaps breeding guidance to avoid breed-associated diseases. Additionally, females were at decreased risk for musculoskeletal issues, which was similarly found in previous studies where males were at increased risk of osteoarthritis (Anderson et al. 2018). These differences may be attributed to hormonal differences based on sex (Hays et al. 2007). Ensuring owners are aware of the increased

risk of particular issues in specific dog types may help to delay the onset of such issues or enable owners to implement effective healthcare for these issues when they do occur, so that the welfare of old age dogs with these issues is maximised.

As one of the top health issues identified in our dataset, dental concerns regarding tartar were investigated further in Chapter four, using a large sample of EHRs this time not constrained to 'old age' dogs, and confirmed our previous finding in Chapter three that Cocker Spaniels have a significant issue in this regard. Cocker Spaniels, Jack Russell Terriers, Springer Spaniels, Cockapoos and Yorkshire Terriers were at increased risk of plaque, tartar, or calculus, compared to Mixed Breeds. In comparison, Labrador Retrievers, Staffordshire Bull Terriers, Border Collies, Shih Tzus, and West Highland White Terriers were at lower risk. Whilst Cocker Spaniels were confirmed to be at increased risk of dental issues, in Chapter three (considering the sample of old age dogs and all dental issues) they were found to be over 2.5 times more likely in comparison to only 1.3 times more likely in Chapter four (when considering dogs of any age and specifically tartar). Further, the Yorkshire Terrier was in fact the breed identified at the most risk at 1.6 times more likely, after a much larger sample allowed analysis of more breeds. These differences may reflect the differences between analysing all dental issues versus tartar, plaque and calculus only, and a larger sample of more breeds made possible by the methodology used in Chapter four, but still highlights Cocker Spaniels as having a particular issue around dental problems and tartar.

In both Chapters three and four, sexually intact females were significantly more at risk of dental issues than sexually intact males. However, in Chapter four, neutered males were at higher risk of tartar and calculus, followed by neutered females, then sexually intact females, when compared to sexually intact males. This indicates an interaction between sex and neuter status, and echoes the

findings about sexually intact dogs from dental issues as a whole. In both chapters, it was confirmed that with each year older a dog gets, the risk of dental issues increases by approximately 10%.

A dog being insured also seemed to indicate an increased risk of presenting with tartar/calculus/plaque. Whilst this may appear counter intuitive, this may be explained by a form of recording bias. This may happen as the veterinarian may feel it a worthwhile and productive conversation with an owner of an insured dog, in comparison to an owner with an uninsured dog who may not be able to afford treatment options. Previous studies have also found that owners of insured dogs spend more when they attend a veterinary practice, and it was suggested that they may purchase more or utilise more services within visits due to the reassurance of having insurance (Williams et al. 2020).

On a similar note, veterinarians were observing and recording dental issues, but in over half of cases appeared not to follow up with a discussion around preventive healthcare measures or treatment options with owners. There also appeared to be a low uptake in treatment options, which may indicate that the issue is not progressing to a stage of needing treatment, or may perhaps indicate a need for understanding why owners choose not to pursue treatments so that alternative and suitable advice can be offered to suit both the needs of the pet's health, but also to suit the owners.

The findings of this project indicate key areas to focus on for the purpose of developing tools and resources to assist with the care of ageing dogs. It is important to ensure that there is an increased awareness in owners of signs to look out for in dogs who are at higher risk of the discussed issues, and to learn from those dogs and owners identified at a lower risk.

5.2 Implications of findings

The findings of this project shed light on the onset of old age in different dog types according to veterinarians, and can inform the development of targeted and tailored canine ageing and wellbeing health messaging and discussion applications for use in veterinary practices. Increasing awareness amongst owners of signs associated with common old age issues may lead to ailments being recognised at the earliest occurrence, rather than being disregarded (or not even noticed) as a normal part of ageing and not requiring intervention. Timely investigation by a veterinarian can ensure appropriate preventive or treatment healthcare can be implemented in order to reduce the likelihood of these common old age issues ever occurring, or prolong the onset of such issues, or at the very least slow down the progression of the issue, so that an old age dog can live out the remainder of its senior years whilst maintaining the highest levels of welfare, quality of life, and the human-animal bond with their owner possible.

5.2.1 Implications of defining old age

Our findings suggest that using previously accepted blanket definitions for when a dog is considered old may not be an accurate approach, and may be excluding old age dogs from studies that aim to identify common issues and the point of onset of these common issues. This is especially important as the point of onset of these issues are likely to be before old age and so become cumulative once a dog has reached this life stage. Instead, guidelines are needed so that veterinary professionals can accurately classify life stages of dogs; senior, elderly, and geriatric for example, and having set age points and states of health at which it is appropriate to use each term. When dealing with individuals, it may be necessary to apply a definition of old age separately for each dog type, depending on their breed, as this factor more than most may influence the onset of old age and associated issues. For example, Cocker Spaniels appear to be considered as old age earlier at 11.7y in comparison to the Jack Russell Terrier at 14.1y. This could again be due to the longer life expectancy

of certain breeds, as previously discussed and found in a previous study (Teng et al. 2022). Thus, perhaps earlier conversations and consequent healthcare interventions to suit specific needs of some breeds, rather than following a one-size fits all approach. A flexible age category approach has been suggested, as the use of age categories which are adjusted according to breed lifespan normalises their early mortality (Harvey 2021). For breeds with short average lifespans this is a welfare issue, as they are at risk of non-normative age related pathologies which should be acknowledged (Harvey 2021).

5.2.2 Implications of focusing on common issues

Our findings suggest a need for veterinarians to ensure owners of particular breeds are aware of the associated signs of these issues to look out for in their dog as they age, and to have conversations around preventive healthcare that can be implemented throughout a dog's earlier life stages to delay, if possible, the onset of these common old age issues. This includes highlighting common issues depending on breed such as dental disease in Cocker Spaniels. It is also important to make breeders aware of common issues in a particular breed, so that careful attention can be applied to ensure no breeding from dogs with these issues occurs. Therefore, whilst it is important to highlight all common old age associated issues to all owners, there should be an emphasis depending on common issues as per different dog types.

This project highlighted a need for veterinarians to engage with owners in conversations around preventive measures for dental issues, and an apparent gap in the uptake of treatment recommendations in owners may also indicate an area for discussion. By engaging in conversations on this topic, measures can be implemented in efforts to reduce the prevalence of this common issue in the old age dog population.

Weight was also a common issue in the old age dogs within these data. Although there is a focus of research on weight gain in dogs due to obesity being a common issue (Courcier et al. 2010; German 2016), our data actually suggested that it was not weight gain, but weight loss, which was the most common issue in old age dogs. It is also interesting to note that a previous study linked weight loss to poor dental health as the issue may prevent adequate nutritional intake (Laflamme 2005). It may be useful to target dogs losing weight into future interventions in order to highlight to veterinarians and owners that this is a common issue which should be identified and investigated.

Tools to promote health messaging and decision making should tailor advice to owners depending on their dog type, as different breeds appear to reach old age sooner than others and so owners of particular breeds should be looking out for important signs of ageing earlier. Common issues in old age dogs may also be more prevalent in different breeds, or different sexes/neuter status, and so once again, any application should factor for this and highlight to owners the signs to look out for if their dog fits those criteria. Prior to the point at which a dog should be considered as reaching old age, health messaging may also offer advice appropriate to the dog's current life stage, such as preventive healthcare to implement throughout puppy or adult ages to address likely issues to appear for that dog when older.

5.3 Limitations

Whilst conducting this project, there were inevitably limitations and challenges encountered.

5.3.1 Limitations of SAVSNET

Whilst using SAVSNET allows for working with large datasets, these data may not necessarily be representative of the entire population. This is in part due to the fact that the data are only collected

from participating practices which are recruited to take part in SAVSNET. The database also only includes vet visiting records (SAVSNET 2020). For example, a dog can only appear in a database if an owner presents it to a veterinary practice which takes part in SAVSNET. Therefore, SAVSNET cannot include data from animals which do not go to veterinarians e.g. stray animals or animals which go to different veterinary practices, some of which may cater for a different demographic, such as charity hospitals.

5.3.2 Limitations of regular expressions

Designing regular expressions to extract relevant consultations which identified dogs being described as having reached old age by a veterinarian was challenging when attempting to incorporate common spelling mistakes, as well as excluding common phrases which may be used in association with the search word. This therefore resulted in varying accuracy of regular expressions. Inaccuracies of the words can in part be attributed to the use of the word in a descriptive context of owners bringing their pets to practice, for example a vet may describe an owner as elderly. However, in the second stage of analysis, the 200 clinical consultation notes per search word were individually read and deemed as to whether or not they met the case definition, ensuring that any consultations taken forward for further analysis of common issues were accurately identified as being from old age dogs. Another factor to consider is the limitation of including spelling variations of search words when designing regular expressions which may in fact lower the accuracy due to matching irrelevant words, as such inclusion of such spellings should be carefully considered.

5.3.3 Limitations of EHRs

Due to the nature of the project, working with electronic health records from primary care practices means that the free text contained narratives around clinical signs and opinions, and as such the

data cannot be referred to as confirmed diagnoses and may be inaccurate or incorrect. Some of the clinical signs mentioned were not able to be categorised into an explicit diagnosis sub-category. For example, if a veterinarian described a clinical sign but was not confident in the evidence to give a firm diagnosis, the clinical sign was sub-categorised separately, so as not to falsely allocate a clinical sign as a definite diagnosis if this was not confirmed in the veterinarian's opinion. Further, these data were analysed retrospectively and therefore it was not possible to pursue further enquiries with the attending practitioner in order to clarify any free text within the electronic health record.

Due to the nature of the text within the electronic health record data, it is difficult to capture everything that may be discussed within a consultation of an old age dog between a veterinarian and owner. To expand, a veterinarian may summarise what was discussed, or perhaps only record some of what was discussed. As a result of this, there may be inaccuracies in the data, for example in terms of the number of issues per dog, as, a veterinarian may not have recorded everything that was discussed or observed during a consult in the free text, leading to underestimations. Similarly, a veterinarian may have only briefly discussed an issue with an owner but not provided clear context in the free text, leading to overestimating the complaints for that dog if it was categorised as a presenting issue. In addition, EHRs may underestimate diseases and their impacts, both on the dog and their owner, if these details are not recorded. Ultimately, due to the nature of the free text clinical health narrative within an electronic health record and how it is used, it is difficult to capture everything that may have occurred within a consultation.

Dogs may have also been recorded as presenting with more than one issue. However, there also may be more than one way of sub-categorising an issue a dog has presented with. If a veterinarian has described the issue in more than one way then both sub-categories will be recorded within the

data, however, this was addressed by modelling a binary outcome yes/no for each condition per dog, rather than the number of times the condition was present in the data.

It is also important to note that the electronic health records used within this project are not written by one veterinarian. The records may be written by a multitude of veterinary professionals, of different training backgrounds. As such, there may be variations in the methods used between and within practices which participate in SAVSNET. For example, some veterinarians may record more detail than others, or some practices may offer different services, or perhaps use different techniques such as the dental grading system previously discussed.

5.3.4 Time limitations

Due to time limitations, it was only possible to work with subsets of data that was available from SAVSNET. As a result, only a small number of breeds were analysed. With more time, larger samples could have been used to represent more breeds within the pet dog population which may have given different findings indicating which breeds are at increased risk within the overall population.

5.4 Future research

5.4.1 Future work on tartar issues

The chosen sub-category for further investigation in Chapter four was prioritised based on clinical importance, number of cases, and potential treatability. As such, it was highlighted as an important issue to incorporate into the future health-related tools and resources.

Although tartar was the condition chosen for deeper investigation, there are still further avenues of enquiry which could be pursued for this common issue in old age dogs. For example, upon reading the electronic health record data associated with this issue, it was observed that some veterinarians would use a grading system when examining a patient's teeth. Whilst designing the dental regular expression, there were consultations that used words or numbers to grade the severity and extent of plaque or tartar. These grades were not included within the regular expression; however, they could be used in future work to capture how the severity of these dental issues progresses over time by using the qualifying words used by veterinary professionals as a form of measurement. For example, some may use the words along a scale of: 'teeth fine', 'some tartar', 'tartar build-up', 'heavy tartar', and 'severe tartar'. It may be interesting to investigate when the issue is first mentioned, which in theory should be at the lower end of the scale as the earlier the intervention the better the prognosis of the issue. Due to time constraints this was not investigated within the study, however this may be used to further explore the severity of which different patients experience dental issues.

It may also be beneficial to understand why veterinarians appear not to be recording a discussion around tartar or calculus issues with over half of owners of dogs which are recorded as having these issues. It is crucial to engage in this conversation in order to tackle this common issue. Future work may investigate veterinarians reasoning for recording a dog as having a dental issue but not having a subsequent discussion with owners regarding treatment options to prevent the progression of the issue or to reverse the effects. It is also paramount that veterinarians highlight preventive measures and signs to look out for to owners. With that being said, veterinarians did appear to be routinely checking for dental issues despite not discussing them with owners, and future work may also entail understanding this aspect of veterinarian perspectives. There also appeared to be a low uptake of treatment advice, and future work may investigate this; perhaps there may be aspects of financial

reasons behind owners not following through with veterinarian advice regarding dental issues, perhaps the dental issues do not often progress to needing treatment, or owners may be reluctant to put their dog through surgery for a dental procedure. It may be beneficial to understand what preventive measures and treatment options appeal to owners to implement within their daily routines in the interests of their pets' health and welfare, as previous studies suggest low uptake in preventive methods such as tooth brushing (Enlund et al. 2020a), and other options such as dietary products have not shown to be as effective (Allan, Adams & Johnston 2019).

Why Cocker Spaniels have such high rates of dental disease and tartar compared to other breeds requires further investigation. The finding of specific breeds at increased risk of plaque, tartar, or calculus may be an area to investigate further. By understanding what it is about breed that alters the risk of these dental issues occurring, appropriate measures can be applied to reduce occurrence in those at higher risk. It may also therefore be beneficial to understand why 1) neutering increases the risk of dental issues, 2) why neutered males are at a higher risk than neutered females, and 3) why sexually intact females are more at risk than sexually intact males. In addition, the reasoning behind insured dogs and an increased risk of dental issues could be investigated further to understand exactly why this is the case.

5.4.2 Future work on osteoarthritis

Another area of concern highlighted in our findings was 'stiffness' which was found in 2.6% of old age dogs, the third most common issue. Osteoarthritis was therefore considered as an issue to investigate further; although there has been a large volume of previous research into osteoarthritis (Anderson et al. 2018; Hart et al. 2014; Hays et al. 2007), it seems there is still room for improvement. This study found a great deal of discussion around old age dogs being 'stiff'. However, earlier intervention when this sign presents itself may help to slow down the progression of

osteoarthritis or improve quality of life by treating it, and so this area may be an area of interest for further research, similar to the investigations done for tartar.

5.4.3 Future work on other common issues

Other sub-categories considered for investigation included vaccination, weight loss, cognitive dysfunction and euthanasia. Although these are common and topical issues in old age dogs, they were not practical to investigate within the scope of this project. Vaccination is relevant in old age dogs, due to the discussion of whether boosters are necessary due to accumulated immunity (Eschle et al. 2020). As such, it is an area of interest to investigate owner and veterinarian attitudes to this issue, to understand these perceptions. However, due to the nature of this project working with electronic health records of primary care patients, the dogs within the dataset are being brought in to practice by their owners, who are perhaps engaged in their pet's healthcare. Therefore, this data will not contain the attitudes or perceptions of owners who do not wish to vaccinate their old age dog, as they simply will not present to practice and will not be within the electronic health records. In order to investigate perceptions of vaccinations further within SAVSNET, a new and complex search would be required, for example incorporating batch numbers into regular expressions. Due to the nature of this data not being a readily available source, it was not within the scope of this project to identify and further analyse such consultations to gain an understanding of vaccination in old age dogs, and so this is a topic for future research. In addition, future work could perhaps aim to understand why weight loss is frequently recorded in old age dogs. It may be that weight loss is readily noticed amongst owners, and something they may go on to present their dog to practice for investigation as a clinical sign or precursor of an underlying illness. However, this was not investigated within this project and requires further study. Exploring canine cognitive dysfunction may also be facilitated by future work as there is some ambiguity around diagnosis, indicated by low rates of diagnosis (Salvin et al. 2010). A greater understanding of this issue will then enable an

increase in owner awareness of canine cognitive dysfunction to negate the impacts on the old age dog population. And finally, investigating euthanasia may compliment the output of this project as this is a matter that is relevant to old age dogs, as the risk of euthanasia increased with age (Pegram et al. 2021). Findings of such work may assist owners in their decision making on end of life care and euthanasia with regards to their old age dogs.

5.4.4 Approaches to future work

When considering these avenues of future work to pursue, it may be beneficial to consider following dogs over time in order to analyse whether the prevalence of issues or advice offered for particular issues varies over time. For example, particular issues may demonstrate peaks at certain points throughout a dog's lifespan, or advice offered may vary depending on the severity of an issue over time. The scale of this work was however beyond the scope of this project but may provide valuable evidence to support efforts in improving the health and welfare of old age dogs.

In order to answer these potential avenues of research, alternative resources of data to SAVSNET may be considered. Given that many of the suggestions are regarding perceptions, experiences, and decision-making, in-depth qualitative research is most suited (Sutton & Austin 2015). Such a study may investigate veterinarian and owner perceptions of old age dogs, and may provide an alternative insight to the work completed here. Ultimately, the findings of a qualitative study may answer questions that the results of a quantitative study cannot answer (Busetto, Wick & Gumbinger 2020).

5.5 Conclusion

A novel data science approach was used to describe when veterinarians consider dogs to be of old age and identify common issues for consultations of old age dogs. Weight loss, stiffness, and tartar

are common signs that require veterinary intervention. Health conditions and ageing trajectory appear to vary between breeds, and veterinarians use various ageing-related words at different ages. There is evidence of breed differences in medical issues associated with old age, as well as evidence of breed, sex and neutering differences in specific dental issues. These findings may indicate a gap in the conversation being had between veterinarians and owners regarding preventive healthcare measures and treatment options for common issues in old age dogs, or other barriers to uptake of advice. These findings could inform the development of tailored health messaging for owners and veterinarians caring for old age dogs. Through identifying the onset of old age and associated issues, it is hoped that resources and interventions can be developed to encourage earlier discussions around a dog's ageing between their owner and veterinarian.

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Appendices

Appendix A

Appendix A: A summary of categorisation of issues recorded when 832 dogs identified as having reached old age by a veterinarian within the SAVSNET database present to practice by breeds (N>10), most common issue as per each breed is indicated in bold.

Breed / (N)								
Median Age / N (Proportion of breed; 95% CI of percentage of dogs presenting within each issue category per breed)								
Category	All dogs / (832)	Mixed Breed / (180)	Retriever (Labrador) / (108)	JRT / (60)	Spaniel (Cocker) / (48)	Border Collie / (47)	Spaniel (Springer) / (36)	SBT / (33)
Auditory	14.06/39(0.05(0.03-0.06))	14.83/6(0.03(0.01-0.06))	13.93/4 (0.04; 0.00-0.07)	16.19/6(0.10(0.02-0.18))	13.805/2(0.04(-0.01-0.10))	0/0(0.00(0.00-0.00))	12.735/2(0.06(-0.02-0.13))	14.7/2(0.06(-0.02-0.14))
Behaviour	13.17/53(0.06(0.05-0.08))	14.06/11(0.06(0.03-0.10))	10.805/6(0.06(0.01-0.10))	16.34/5(0.08(0.01-0.15))	13.13/5(0.10(0.02-0.19))	12.5/2(0.04(-0.02-0.10))	12.15/5(0.14(0.03-0.25))	13.44/3(0.09(-0.01-0.19))
Cardiopulmonary	13.595/152(0.18(0.16-0.21))	14.04/32(0.18(0.12-0.23))	12.51/21(0.19(0.12-0.27))	15.85/17(0.28(0.17-0.40))	13.09/5(0.10(0.02-0.19))	14.365/6(0.13(0.03-0.22))	10.81/3(0.08(-0.01-0.17))	12.815/6(0.18(0.05-0.31))
Dental	13/254(0.31(0.27-0.34))	13.72/49(0.27(0.21-0.34))	12.34/31(0.29(0.20-0.37))	**14.35/25(0.42(0.29-0.54))**	12.49/23(0.48(0.34-0.62))	13.03/13(0.28(0.15-0.40))	13.16/9(0.25(0.11-0.39))	12.68/13(0.39(0.23-0.56))
Digestive	12.78/187(0.22(0.20-0.25))	13.9/40(0.22(0.16-0.28))	12.97/17(0.16(0.09-0.23))	14.35/15(0.25(0.14-0.36))	11.52/11(0.23(0.11-0.35))	12.56/12(0.26(0.13-0.38))	11.26/7(0.19(0.07-0.32))	13.1/6(0.18(0.05-0.31))
Endocrine	12.27/7(0.01(0.00-0.01))	11.19/1(0.01(-0.01-0.02))	10.71/1(0.01(-0.01-0.03))	0/0(0.00(0.00-0.00))	9.45/1(0.02(-0.02-0.06))	0/0(0.00(0.00-0.00))	12.31/1(0.03(-0.03-0.08))	0/0(0.00(0.00-0.00))
Euthanised	13.76/37(0.04(0.03-0.06))	14.81/7(0.04(0.01-0.07))	13.59/3(0.03(0.00-0.06))	16.42/5(0.08(0.01-0.15))	0/0(0.00(0.00-0.00))	12.7/3(0.06(-0.01-0.13))	14.31/1(0.03(-0.03-0.08))	15.135/2(0.06(-0.02-0.14))
Immunological	12.015/156(0.19(0.16-0.21))	12.08/32(0.18(0.12-0.23))	11.2/26(0.24(0.16-0.32))	13.17/11(0.18(0.09-0.28))	11.87/9(0.19(0.08-0.30))	12.85/7(0.15(0.05-0.25))	12.33/5(0.14(0.03-0.25))	12.31/7(0.21(0.07-0.35))
Integument	12.15/235(0.28(0.25-0.31))	12.815/48(0.27(0.20-0.33))	11.415/32(0.30(0.21-0.38))	14.01/17(0.28(0.17-0.40))	11.4/13(0.27(0.15-0.40))	14.64/9(0.19(0.08-0.30))	12.15/7(0.19(0.07-0.32))	11.81/4(0.12(0.01-0.23))
Microchip	11.49/24(0.03(0.02-0.04))	11.34/5(0.03(0.00-0.05))	11.21/5(0.05(0.01-0.09))	14.715/2(0.03(-0.01-0.08))	12.8/2(0.04(-0.01-0.10))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	10.51/3(0.09(-0.01-0.19))
Musculoskeletal	12.945/278(0.33(0.30-0.37))	**13.1/72(0.40(0.33-0.47))**	**12.145/48(0.44(0.35-0.54))**	15.09/17(0.28(0.17-0.40))	12.14/9(0.19(0.08-0.30))	12.99/16(0.34(0.20-0.48))	**13.355/16(0.44(0.28-0.61))**	11.62/10(0.30(0.15-0.46))
Neoplasia	12.595/164(0.20(0.17-0.22))	13.54/36(0.20(0.14-0.26))	11.94/26(0.24(0.16-0.32))	13.98/10(0.17(0.07-0.26))	13.015/10(0.21(0.09-0.32))	11.24/9(0.19(0.08-0.30))	11.28/11(0.31(0.16-0.46))	12.96/11(0.33(0.17-0.49))
Neurological	13.28/93(0.11(0.09-0.13))	14.06/15(0.08(0.04-0.12))	11.94/9(0.08(0.03-0.14))	16.03/8(0.13(0.05-0.22))	13.035/6(0.13(0.03-0.22))	13.765/10(0.21(0.10-0.33))	13.425/8(0.22(0.09-0.36))	13.44/7(0.21(0.07-0.35))

No features Found	12.77/20(0.02(0.01-0.03))	13.23/5(0.03(0.00-0.05))	14/3(0.03(0.00-0.06))	13.94/1(0.02(-0.02-0.05))	0/0(0.00(0.00-0.00))	11.44/1(0.02(-0.02-0.06))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))
Ocular	13.08/163(0.20(0.17-0.22))	14.14/35(0.19(0.14-0.25))	12.245/24(0.22(0.14-0.30))	15.355/16(0.27(0.15-0.38))	12.5/15(0.31(0.18-0.44))	13.14/3(0.06(-0.01-0.13))	12.735/6(0.17(0.04-0.29))	12.495/10(0.30(0.15-0.46))
Other	14.81/1(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))
Parasites	11.595/14(0.02(0.01-0.03))	9.95/3(0.02(0.00-0.04))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	12.5/1(0.02(-0.02-0.06))	12.95/1(0.02(-0.02-0.06))	11.39/1(0.03(-0.03-0.08))	0/0(0.00(0.00-0.00))
Reproductive	14.85/9(0.01(0.00-0.02))	12/1(0.01(-0.01-0.02))	9.33/1(0.01(-0.01-0.03))	15.635/2(0.03(-0.01-0.08))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	16.44/1(0.03(-0.03-0.09))
Travel	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))
Urinary	13.17/117(0.14(0.12-0.16))	14.44/17(0.09(0.05-0.14))	12.885/12(0.11(0.05-0.17))	15.75/8(0.13(0.05-0.22))	12.05/9(0.19(0.08-0.30))	13.785/6(0.13(0.03-0.22))	12.68/6(0.17(0.04-0.29))	13.165/6(0.18(0.05-0.31))
Weight	**12/289(0.35(0.32-0.38))**	13.2/65(0.36(0.29-0.43))	11.575/38(0.35(0.26-0.44))	11.16/16(0.27(0.15-0.38))	**11.635/22(0.46(0.32-0.60))**	**12.01/17(0.36(0.22-0.50))**	11.56/10(0.28(0.13-0.42))	**10.57/14(0.42(0.26-0.59))**

Breed / (N)								
Median Age / N (Proportion of breed; 95% CI of percentage of dogs presenting within each issue category per breed)								
Category	WHWT / (31)	Retriever (Golden) / (27)	Border Terrier / (21)	Shih Tzu / (19)	Yorkshire Terrier / (14)	CKCS / (13)	GSD / (12)	Other / (184)
Auditory	0/0(0.00(0.00-0.00))	15.76/1(0.04(-0.03-0.11))	0/0(0.00(0.00-0.00))	10.59/1(0.05(-0.05-0.15))	14.1/2(0.14(-0.04-0.33))	12.77/3(0.23(0.00-0.46))	0/0(0.00(0.00-0.00))	12.79/10(0.05(0.02-0.09))
Behaviour	15/3(0.10(-0.01-0.20))	10.72/1(0.04(-0.03-0.11))	13.71/2(0.10(-0.03-0.22))	13.675/2(0.11(-0.03-0.24))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	12.94/8(0.04(0.01-0.07))
Cardiopulmonary	13.62/7(0.23(0.08-0.37))	11.945/2(0.07(-0.02-0.17))	14.195/2(0.10(-0.03-0.22))	14.34/2(0.11(-0.03-0.24))	**15.065/6(0.43(0.17-0.69))**	**11.72/6(0.46(0.19-0.73))**	9.25/1(0.08(-0.07-0.24))	12.365/36(0.20(0.14-0.25))
Dental	14.61/9(0.29(0.13-0.45))	12.32/6(0.22(0.07-0.38))	**13.62/9(0.43(0.22-0.64))**	11.76/4(0.21(0.03-0.39))	13.16/4(0.29(0.05-0.52))	**9.36/6(0.46(0.19-0.73))**	9.34/3(0.25(0.01-0.50))	12.69/50(0.27(0.21-0.34))
Digestive	13.41/5(0.16(0.03-0.29))	12.47/4(0.15(0.01-0.28))	10.48/3(0.14(-0.01-0.29))	12.84/3(0.16(-0.01-0.32))	11.35/3(0.21(0.00-0.43))	9.775/2(0.15(-0.04-0.35))	11.37/5(0.42(0.14-0.70))	11.49/54(0.30(0.23-0.36))
Endocrine	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	14.93/1(0.05(-0.04-0.14))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	12.365/2(0.01(0.00-0.03))
Euthanised	15/1(0.03(-0.03-0.09))	13.51/2(0.07(-0.02-0.17))	13.57/3(0.14(-0.01-0.29))	14.57/1(0.05(-0.05-0.15))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	13/9(0.05(0.02-0.08))
Immunological	13.99/4(0.13(0.01-0.25))	13.13/5(0.19(0.04-0.33))	12.71/6(0.29(0.09-0.48))	12.84/3(0.16(-0.01-0.32))	13.2/1(0.07(-0.06-0.21))	10.83/2(0.15(-0.04-0.35))	11.2/2(0.17(-0.04-0.38))	10.53/36(0.20(0.14-0.25))
Integument	13.16/10(0.32(0.16-0.49))	12.41/12(0.44(0.26-0.63))	14.93/5(0.24(0.06-0.42))	**11.5/8(0.42(0.20-0.64))**	15/5(0.36(0.11-0.61))	10.67/3(0.23(0.00-0.46))	11.16/7(0.58(0.30-0.86))	11.66/55(0.30(0.23-0.37))

Microchip	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	13.2/1(0.07(-0.06-0.21))	12.77/1(0.08(-0.07-0.22))	12.92/1(0.08(-0.07-0.24))	10.825/4(0.02(0.00-0.04))
Musculoskeletal	13.59/7(0.23(0.08-0.37))	**13.13/15(0.56(0.37-0.74))**	13.62/5(0.24(0.06-0.42))	14.25/3(0.16(-0.01-0.32))	15.13/3(0.21(0.00-0.43))	15.17/1(0.08(-0.07-0.22))	**9.4/8(0.67(0.40-0.93))**	12.365/48(0.26(0.20-0.33))
Neoplasia	14.82/3(0.10(-0.01-0.20))	12.21/4(0.15(0.01-0.28))	0/0(0.00(0.00-0.00))	13.1/5(0.26(0.07-0.46))	13.12/3(0.21(0.00-0.43))	13.18/1(0.08(-0.07-0.22))	10.32/2(0.17(-0.04-0.38))	12.01/33(0.18(0.12-0.24))
Neurological	15.71/2(0.06(-0.02-0.15))	12.295/4(0.15(0.01-0.28))	13.62/5(0.24(0.06-0.42))	14.51/3(0.16(-0.01-0.32))	11.35/1(0.07(-0.06-0.21))	7.695/2(0.15(-0.04-0.35))	0/0(0.00(0.00-0.00))	11.31/13(0.07(0.03-0.11))
No features Found	11.61/3(0.10(-0.01-0.20))	10.31/3(0.11(-0.01-0.23))	10.7/1(0.05(-0.04-0.14))	11.87/1(0.05(-0.05-0.15))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	13.885/2(0.01(0.00-0.03))
Ocular	14.035/2(0.06(-0.02-0.15))	13.15/3(0.11(-0.01-0.23))	14.72/5(0.24(0.06-0.42))	12.31/7(0.37(0.15-0.59))	13.905/4(0.29(0.05-0.52))	14.745/4(0.31(0.06-0.56))	13.06/1(0.08(-0.07-0.24))	11.77/28(0.15(0.10-0.21))
Other	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	14.81/1(0.01(-0.01-0.02))
Parasites	12.18/1(0.03(-0.03-0.09))	0/0(0.00(0.00-0.00))	11.8/1(0.05(-0.04-0.14))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	9.25/1(0.08(-0.07-0.24))	10.81/5(0.03(0.00-0.05))
Reproductive	12.34/1(0.03(-0.03-0.09))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	15.5/3(0.02(0.00-0.03))
Travel	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))	0/0(0.00(0.00-0.00))
Urinary	13.475/4(0.13(0.01-0.25))	12.295/4(0.15(0.01-0.28))	10.48/3(0.14(-0.01-0.29))	12.46/5(0.26(0.07-0.46))	12.235/2(0.14(-0.04-0.33))	0/0(0.00(0.00-0.00))	9.41/3(0.25(0.01-0.50))	12.905/32(0.17(0.12-0.23))
Weight	**13.695/8(0.26(0.10-0.41))**	10.36/10(0.37(0.19-0.55))	11.8/7(0.33(0.13-0.53))	13.445/6(0.32(0.11-0.52))	14.1/4(0.29(0.05-0.52))	7.34/3(0.23(0.00-0.46))	9.25/3(0.25(0.01-0.50))	**11.705/66(0.36(0.29-0.43))**

Appendix A: JRT - Jack Russell Terrier. SBT – Staffordshire Bull Terrier. WHWT – West Highland White Terrier. CKCS – Cavalier King Charles Spaniel. GSD – German Shepherd Dog.

Appendix B

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Auditory' from the OAD sub-sample.

Auditory		
Clinical sub-category	**Count**	**Median Age (y)**
Causes of hearing loss - discussed	2	9.4
Hearing loss	38	14.1
Hearing tested	1	13.1
Post-operative hearing loss - discussed	1	12.5
Total	42	

Appendix C

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Behaviour' from the OAD sub-sample.

Behaviour		
Clinical sub-category	**Count**	**Median Age (y)**
Aggression	8	13.2
Anxiety	1	12.8
Barking	11	14.4
Behaviour - altered	4	14.1
Confused	9	15.9
Cowering	1	14.1
Dementia	1	14.8
Inappropriate urination	3	17.0
Mood change	1	11.3
Nervous	1	11.2
Pacing	2	13.9
Restless	1	14.8
Senile	4	12.9
Separation anxiety	5	12.5
Sleeping deeply	1	13.2
Sleeping more	3	14.8
Staring	5	11.3
Stressed	3	11.2
Unsettled at night	9	13.2
Wandering	2	14.6
Total	75	

Appendix D

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Cardiopulmonary' from the OAD sub-sample.

Cardiopulmonary		
Clinical sub-category	**Count**	**Median Age (y)**
Altered breathing	1	13.3
Arrhythmia	5	15.9
Arrhythmia - sinus	4	12.5
Arrhythmia - tachycardia	2	15.0
Atrial fibrillation	1	13.0
Blood pressure - discussed	1	15.2
Blood pressure - recorded	1	8.9
Bradycardia	2	16.3
Breathing issues	2	16.2
Bronchitis	1	15.0
Cardiac cachexia	1	8.6
Cardiomegaly	1	15.6
Cough/retch	2	11.9
Coughing	42	13.6
Coughing- when pulls	1	18.2
Dyspnoea	1	12.6
Dysrhythmia	1	11.2
Epistaxis	2	10.7
Harsh breathing	2	15.0
Heart sounds - unusual	1	10.0
Increased respiratory noise	1	16.9
Irregular heartrate	1	10.2
Laryngeal hemiplegia	1	12.0
Laryngeal paralysis	2	13.4
Laryngeal paralysis polyneuropathy	1	11.0
Laryngitis	1	13.1
Lung sounds increased	2	14.4
Metastases	1	15.0
Murmur	57	14.4
Nasal discharge	1	14.3
Noisy breathing	1	11.2
Panting	6	13.3
Pulmonary oedema	1	15.4
Respiratory effort	4	12.0
Sneezing	1	14.8
Sternal contact	1	15.6
Syncopal episode	1	7.7
Tachycardia	2	15.2
Tachypnoea	1	13.6
Trachea - retch	1	14.9
Tracheitis	1	14.7
URT sounds	2	14.6

Wheezy	5	13.0
Total	169	

Appendix E

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Dental' from the OAD sub-sample.

Dental		
Clinical sub-category	**Count**	**Median Age (y)**
Abscess	3	14.6
Abscess - suspected	1	11.2
Calculus	18	12.3
Dental - advised	12	12.5
Dental - check up	2	11.1
Dental - discussed	1	14.9
Dental - extraction	1	9.0
Dental care advice	5	9.3
Dental disease	30	13.2
Dental disease - unspecified	1	12.9
Dental needed - extraction	3	8.3
Epulis	3	11.2
Gingival disease - not specified	1	14.2
Gingival hyperplasia	7	13.3
Gingival pigmentation altered	1	13.1
Gingival recession	7	12.1
Gingivitis	32	12.2
Halitosis	29	14.4
Hyperplasia	1	14.4
Needs dental	1	14.3
Periodontal disease	12	14.6
Plaque	21	13.1
Staining	7	9.0
Stomatitis	1	14.3
Swollen	2	11.6
Tartar	109	12.3
Teeth - broken	3	13.0
Teeth - discoloured	1	12.2
Teeth - fracture	2	13.5
Teeth - infected	1	14.1
Teeth - loose	1	14.8
Teeth - missing	5	13.2
Teeth - needs removing	1	13.3
Teeth - poor	25	14.3
Teeth - purulent	1	12.5
Teeth - removed	1	11.3
Teeth - rotten	2	15.0
Teeth - worn	5	11.7
Tooth root abscess	2	12.1
Ulcer	1	13.4
Total	362	

Appendix F

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Digestive'.

Digestive		
Clinical sub-category	**Count**	**Median Age (y)**
Abdomen	5	14.1
Abdomen - bloat	1	16.3
Abdomen - distended	7	14.2
Abdomen - pain	3	9.6
Abdomen - tense	11	12.9
Abdomen Mass	1	11.5
Appetite - discussed	1	15.3
Appetite - improved	2	15.6
Ascites	1	15.0
Bile	1	11.4
Borborygmi	1	11.1
Cause of vomit - unsure	1	9.7
Colitis	2	12.3
Constipated	3	10.4
Diarrhoea	29	12.9
Diarrhoea - blood	6	13.4
Diarrhoea - haemorrhagic	1	20.4
Diarrhoea - improved	2	15.6
Diarrhoea - intermittent	1	11.0
Diarrhoea - mucus	2	14.2
Diet - discussed	17	10.0
Faecal incontinence	22	13.9
Faeces - blood	1	12.7
Faeces - mucus	2	10.5
Faeces - soft	13	12.5
Flatulence	6	10.5
Gastroenteritis	2	12.2
Gastrotomy - check up	1	13.3
Inappetent	32	12.7
Oral mass	1	15.0
Pancreatitis - suspected	1	13.1
Pot belly	3	11.6
Retching	2	13.8
Spleen - enlarged	1	11.5
Stool - discoloured	1	16.3
Stool - hard	1	8.9
Straining	3	9.6
Vomiting	39	12.2
Vomiting - blood	1	14.6
Total	230	

Appendix G

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Endocrine'.

Endocrine		
Clinical sub-category	**Count**	**Median Age (y)**
Cushing's	1	12.3
Endocrine disease	1	12.3
Hypothyroid	3	11.2
Insulin - discussion	2	12.8
Tail gland hyperplasia	1	12.3
Total	8	

Appendix H

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Euthanasia'.

Euthanasia		
Clinical sub-category	**Count**	**Median Age (y)**
Euthanasia - completed	18	14.3
Euthanasia - discussed	19	13.8
Total	37	

Appendix I

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Immunological'.

Immunological		
Clinical sub-category	**Count**	**Median Age (y)**
Lymph Nodes	11	14.3
Vaccination	66	11.9
Vaccination - declined - HPC	1	14.8
Vaccination - declined - KC	6	12.2
Vaccination - DHP	12	12.5
Vaccination - DHPL	2	11.5
Vaccination - DHPPi	3	9.8
Vaccination - exam	2	12.7
Vaccination - KC	32	11.3
Vaccination - L2	1	15.2
Vaccination - L4	52	11.5
Vaccination - Lepto	4	13.3
Vaccination - overdue	1	13.2
Vaccination - part	1	13.6
Vaccination - Pi	2	10.8
Vaccination - Rabies	1	13.0
Vaccination - restart	7	8.3
Vaccination - restart - DHP	2	10.1
Vaccination - restart - L4	3	12.8
Total	209	

Appendix J

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Integument'.

Integument		
Clinical sub-category	**Count**	**Median Age (y)**
Abscess	1	16.2
Adenoma	1	15.9
Alopecia	13	11.3
Anal gland – furunculosis	1	11.4
Anal glands	25	12.0
Anus – faeces	1	11.4
Coat – checked	1	14.2
Coat – clipped	1	15.8
Coat – dry	1	10.6
Coat – matted	7	15.0
Cyst	12	12.9
Dermatitis	3	11.6
Discharge	1	15.4
Ear – aural haematoma	4	11.2
Ear – checked	1	16.4
Ear – dirty	23	10.6
Ear – discharge	3	14.9
Ear – inflammation	3	10.7
Ear – itchy	1	13.0
Ear – lesion	1	11.2
Ear – otitis externa	13	13.2
Ear – pigmented	1	9.9
Ear – stenotic	4	13.3
Ear – swollen	1	12.7
Erythema	8	9.7
Fatty lump	2	11.7
Flea dirt	1	15.0
Graze	1	13.1
Hair loss	3	11.0
Hives	1	8.5
Inflammation	2	12.4
Interdigital inflammation	2	10.4
Interdigital staining	1	8.0
Interdigital swelling	1	9.3
Itching	1	14.8
Lesion	1	11.7
Licking	2	13.1
Lip lesion	1	14.4
Maggots	1	16.0
Mass	1	14.9
Melassezia	1	15.0
Nail – broken	2	14.0
Nail – checked	1	7.5

Nail – clipped	28	12.0
Nail – long	4	14.6
Nail – ripped	1	13.2
Papilloma	1	13.8
Paw pads	2	8.6
Perianal lesion	1	11.2
Pigmentation	5	11.7
Pruritus	10	9.9
Pyoderma	2	10.7
Saliva staining	2	13.3
Seborrhoea	1	15.0
Skin – allergy	5	13.6
Skin – comodones	2	12.9
Skin – crusty	1	5.6
Skin – dandruff	1	9.3
Skin – flaky/scaly	5	12.1
Skin – flare up	1	14.0
Skin – greasy	1	15.0
Skin – pigment	1	7.1
Skin – scab	7	12.1
Skin – scurfy	1	13.1
Skin – sore	3	14.0
Skin – spot	1	10.8
Skin – thickened	3	10.7
Skin – ulcer	3	11.2
Skin – worse	1	12.7
Skin tags	2	13.2
Warts	12	12.7
Wound	1	8.3
Wound – bite	1	7.3
Wound – check up	1	12.9
Wound – check up surgical wound	1	7.1
Wound – infection	1	9.3
Wound – scratch	1	13.6
Yeast exudate	1	7.6
Total	270	

Appendix K

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Microchip'.

Microchip		
Clinical sub-category	**Count**	**Median Age (y)**
Microchip - checked	21	11.3
Microchip - discussed	2	12.0
Microchip - implanted	1	12.9
Total	24	

Appendix L

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Musculoskeletal'.

Musculoskeletal		
Clinical sub-category	**Count**	**Median Age (y)**
AC - rupture	1	15.4
Arthritis	29	12.9
Back pain	1	10.5
Carpus - swollen	1	7.8
Crepitus	9	11.2
Cruciate – damage	1	13.2
Discomfort	2	12.7
DJD	3	12.5
Dysplasia	1	7.8
Elbow – dysplasia	1	3.4
Elbow – examine	1	12.1
Elbow – swollen	2	8.8
Fore legs - lameness	1	15.0
Fore legs – pain	1	11.3
Fore legs – weak	1	14.1
Gait altered	4	12.3
Hernia – diaphragm	1	12.7
Hind legs - dragging	3	14.8
Hind legs – hocked	1	12.1
Hind legs – weak	19	13.6
Hip dysplasia	1	7.7
Hips – examine	1	12.1
Hock – thickened	1	14.0
Hunched	2	11.2
Joint supplement	1	9.9
Lameness	52	12.0
Legs – weak	5	13.6
Loss of muscle mass	40	13.4
Mobility	13	13.7
Osteoarthritis	25	12.2
Osteomyelitis	1	12.8
Pain	7	10.1
Patella – luxation	2	11.9
Paw – pain	1	12.3
Proprioceptive deficit	3	14.0
Reduced ROM	21	13.0
Slowing down/reduced activity	20	12.1
Soft tissue pain	1	10.1
Stance – altered	2	14.6
Stiff	60	12.8
Stifle	1	8.6
Stifle – crepitus	1	13.1
Stifle – swollen	1	15.4

Stifle – thickened	4	13.3
Twitching	2	14.2
Unknown	1	12.7
Varus posture	1	11.3
Weakness	22	13.5
Total	375	

Appendix M

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Neoplasia'.

Neoplasia		
Clinical sub-category	**Count**	**Median Age (y)**
Adenoma	4	13.5
Cyst	3	14.5
Dorsal hole	1	10.3
Epulis	1	9.0
FNA – advise	2	10.3
FNA – done	1	11.8
Lipoma	8	13.1
Lipoma – abdomen	3	13.4
Lipoma – carpus	1	10.6
Lipoma – chest	2	10.9
Lipoma – chin	1	11.9
Lipoma – elbow	1	15.0
Lipoma – flank	1	8.6
Lipoma – groin	1	8.9
Lipoma – inguinum	1	11.6
Lipoma – leg	1	8.3
Lipoma – ribs	4	12.8
Lipoma – shoulder	2	11.4
Lipoma – suspected	1	11.5
Lipoma – tail	1	13.5
Lipoma – thorax	2	15.9
Mass – abdomen	4	12.5
Mass – anal	1	11.7
Mass – antebrachium	1	15.4
Mass – axilla	3	10.0
Mass – carpus	1	10.6
Mass – chest	6	11.7
Mass – dorsal	3	13.3
Mass – ear	2	12.9
Mass – elbow	3	13.1
Mass – eyelid	4	11.1
Mass – face	1	8.3
Mass – flank	9	12.1
Mass – foot	1	12.7
Mass – head	1	11.0
Mass – hock	1	7.8
Mass – inguinum	2	10.5
Mass – leg	4	12.4
Mass – limbs	1	12.1
Mass – lip	1	14.4
Mass – liver	1	13.1
Mass – lumbar	1	10.9
Mass – mammary	11	12.3

Mass – mandibular	2	12.9
Mass – metatarsal	1	13.3
Mass – muzzle	1	14.3
Mass – neck	1	8.9
Mass – nose	1	10.1
Mass – oral	5	15.0
Mass – paw	1	10.6
Mass – perianal	5	12.5
Mass – ribs	3	10.4
Mass – shoulder	5	11.3
Mass – sternum	1	11.2
Mass – stifle	2	8.6
Mass – testicle	1	16.4
Mass – thigh	1	13.4
Mass – thorax	2	11.3
Mass – trunk	2	11.8
Mass – umbilicus	1	9.9
Mass – vagina	1	12.1
Mass – vaginal	1	15.0
Mass – ventrum	3	12.1
Mass/Lumps	30	13.0
Neoplasia	2	12.0
Neoplasia – duodenal	1	14.6
Neoplasia – gastric	1	14.6
Neoplasia – suspected	2	15.8
Neoplasia – unspecified	1	11.2
Papilloma	1	13.8
Prostatic carcinoma	1	16.3
Removal	1	10.1
Skin tag	2	14.4
Thorax – mass	1	19.8
Tumour – mammary	1	12.9
Tumour – size increased	1	14.2
Tumour – testicular	1	13.7
Wart	10	13.6
Total	200	

Appendix N

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Neurological'.

Neurological		
Clinical sub-category	**Count**	**Median Age (y)**
Anxiety	1	12.8
Ataxia	8	13.3
Brain ageing	19	14.4
Brain tumour	3	11.8
Cognitive dysfunction	10	12.9
Collapsed	3	13.6
Head tilt	6	13.5
Horner's syndrome	1	7.3
Intracranial lesion	1	13.3
Muscular spasm	1	13.4
Myelopathy	1	12.3
Neurological degeneration	2	12.4
Nystagmus	4	13.9
Paresis	2	14.9
Payoxysmal dyskinesia	1	7.4
Proprioceptive deficit	23	12.9
Seizure	10	12.5
Stroke	1	13.9
Tremors	4	12.0
Vestibular disease	1	8.1
Vestibular syndrome	5	14.2
Total	107	

Appendix O

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Ocular'.

Ocular		
Clinical sub-category	**Count**	**Median Age (y)**
Age related changes	14	11.2
Blind	15	14.4
Blue	3	12.1
Cataracts	53	13.4
Cherry eye	2	10.7
Clouding	9	11.8
Conjunctiva - swollen	1	13.7
Conjunctivitis	5	13.2
Cornea - blue scarring	1	13.1
Cornea - cholesterol	1	9.3
Cornea - lesion	1	12.3
Cornea - scarring	1	16.3
Cornea - white ring	1	13.7
Discharge	10	12.5
Entropian	1	13.0
Exophthalmos (protruding eye)	1	14.5
Eye - abnormal	3	11.0
Eye - discharge	5	12.6
Eye - dry	1	14.6
Eye - watery	1	11.3
Eyelid mass	1	11.0
Horner's syndrome	1	10.7
Inflammation	3	12.6
Keratoconjunctivitis sicca	2	14.3
Lens fibrosis	1	12.6
Measured intraocular pressure	2	10.5
Nictitans protrusion	1	10.4
Nuclear degeneration	1	16.2
Nuclear sclerosis	3	11.3
Nystagmus	1	13.0
Ocular disease	1	16.7
Opacity	4	14.5
Opalescent lens	1	13.7
PLR - reduced	1	8.0
Protruding third eyelid	1	10.0
Pupil - dilated	1	8.0
Reduced PLR	1	17.7
Sclera - yellow	1	12.3
Sclerosis	31	13.4
Ventral deviation	1	13.4
Vision - reduced	17	13.0
Total	205	

Appendix P

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Parasites'.

Parasites		
Clinical sub-category	**Count**	**Median Age (y)**
Discuss anti-parasite treatment	3	12.2
Dispense anti-parasite treatment	3	11.4
Fleas	5	12.5
Parasite check	1	13.2
Tick bite	1	10.8
Tick removed	1	9.0
Total	14	

Appendix Q

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Reproductive'.

Reproductive		
Clinical sub-category	**Count**	**Median Age (y)**
Discuss reproductive cycle	2	10.7
Genital check	4	12.9
Most recent season - unknown	1	9.3
Prostatic carcinoma	1	16.3
Pseudo-pregnancy	1	12.0
Pyometra - discussed	3	12.3
Vaginal discharge	2	15.2
Total	14	

Appendix R

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Urinary'.

Urinary		
Clinical sub-category	**Count**	**Median Age (y)**
Altered urination	3	12.8
Cystitis	2	13.4
Dehydration	1	13.3
Drinking less	2	13.5
Haematuria	2	16.0
Incontinence	44	13.9
Kidney disease	3	13.8
Pollakiuria	1	6.5
Polydipsia	20	11.7
Polydipsia - suspect	1	19.8
Polyuria	3	13.2
Polyuria and polydipsia	31	11.8
Polyuria and polydipsia – vet unsure	2	12.2
Prostatic disease	1	8.9
Pseudomonas UTI	1	14.6
Renal	1	14.6
Urine - blood	1	15.0
Urine - cystocentesis sample	1	14.6
Urine - dilute	1	13.3
Urine - infected	1	12.3
Urine - large volume	1	14.6
Urine - pink	1	10.8
Urine - smell	1	13.3
Urine - specific gravity	2	14.4
Urine - staining	1	12.5
UTI	1	12.5
Total	129	

Appendix S

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Weight'.

Weight		
Clinical sub-category	**Count**	**Median Age (y)**
BCS 1/5	1	15.3
BCS 1/9	1	14.8
BCS 2/9	3	10.7
BCS 3	1	9.8
BCS 3.5/5	3	11.8
BCS 3/5	5	11.7
BCS 3/7	1	14.2
BCS 3/9	2	12.3
BCS 4.5	1	11.3
BCS 4.5/5	1	11.7
BCS 4.5/9	2	13.2
BCS 4/5	5	15.0
BCS 4/6	1	8.1
BCS 4/9	10	14.6
BCS 4-5	1	9.4
BCS 4-5/9	3	12.5
BCS 5	1	8.0
BCS 5/5	1	13.9
BCS 5/9	18	12.1
BCS 6/9	5	9.3
BCS 6-7/9	2	11.0
BCS 7/9	15	10.6
BCS 8.5/9	1	8.2
BCS 8/9	6	10.2
BCS 8-9/9	1	12.5
BFI 45%	1	8.0
Diet – discussed	24	8.5
Ideal	5	12.7
Ideal – BCS recorded	47	12.4
Inappetent	4	14.6
Obese	2	13.5
Obese – BCS recorded	9	10.2
Overweight	18	10.3
Overweight – BCS recorded	26	10.5
Poor body condition	8	11.5
Underweight	7	12.2
Underweight – BCS recorded	8	13.3
Weight – discussed	17	9.8
Weight – measured	2	10.4
Weight – recorded	27	12.0
Weight – stable	6	13.4
Weight gain	35	11.4
Weight loss	93	13.2
Weight loss – advised	11	11.7
Weight loss – discussed	1	5.2
Weight loss – intentional	4	11.4
Weight loss – unintentional	10	13.9
Weight loss – vet unsure	1	10.0
Total	457	

Appendix T

Identified sub-categories and the corresponding count and median age of dogs recorded within the major category of 'Other'.

Other		
Clinical sub-category	**Count**	**Median Age (y)**
Unknown	1	14.81

Appendix U

Count of breeds included in the OAD sub-sample (832).

Breed	**Count N (%)**
Mixed Breed	180 (21.6)
Retriever (Labrador)	108 (13.0)
Jack Russell Terrier	60 (7.2)
Spaniel (Cocker)	48 (5.8)
Border Collie	47 (5.6)
Spaniel (Springer)	36 (4.3)
Staffordshire Bull Terrier	33 (4.0)
West Highland White Terrier	31 (3.7)
Retriever (Golden)	27 (3.2)
Border Terrier	21 (2.5)
Shih Tzu	19 (2.3)
Yorkshire Terrier	14 (1.7)
Cavalier King Charles Spaniel	13 (1.6)
German Shepherd Dog (Alsatian)	12 (1.4)
Miniature Schnauzer	9 (1.1)
Boxer	9 (1.1)
Bichon Frise	8 (1.0)
Poodle (Miniature)	8 (1.0)
Greyhound	7 (0.8)
Poodle (generic)	6 (0.7)
Lurcher	6 (0.7)
Tibetan Terrier	5 (0.6)
Terrier (Generic)	5 (0.6)
Beagle	5 (0.6)
Pug	5 (0.6)
Cairn Terrier	4 (0.5)
Hungarian Vizsla	4 (0.5)
Dachshund	4 (0.5)
Siberian Husky	4 (0.5)
Labradoodle	4 (0.5)
Lhasa Apso	4 (0.5)
Bedlington Terrier	4 (0.5)
Spaniel (English Springer)	4 (0.5)
Lakeland Terrier	4 (0.5)
Great Dane	3 (0.4)
Collie (Rough)	3 (0.4)
Rhodesian Ridgeback	3 (0.4)
Cockapoo	3 (0.4)
Retriever (Generic)	3 (0.4)
Spaniel (American Cocker)	2 (0.2)
Bull Terrier	2 (0.2)
Spaniel (Generic)	2 (0.2)
Pomeranian	2 (0.2)
Dobermann	2 (0.2)
Collie (Generic)	2 (0.2)

French Bulldog	2 (0.2)
Irish Terrier	2 (0.2)
Bearded Collie	2 (0.2)
Saluki	2 (0.2)
Shar-Pei	2 (0.2)
Whippet	2 (0.2)
Welsh Terrier	1 (0.1)
Maltese	1 (0.1)
Chinese Crested	1 (0.1)
Old English Sheepdog	1 (0.1)
Bernese Mountain Dog	1 (0.1)
Papillon	1 (0.1)
Large Munsterlander	1 (0.1)
Patterdale Terrier	1 (0.1)
Collie (Smooth)	1 (0.1)
Pointer	1 (0.1)
Miniature Pinscher	1 (0.1)
King Charles Spaniel	1 (0.1)
Chihuahua	1 (0.1)
Bulldog	1 (0.1)
Australian Kelpie	1 (0.1)
Husky (generic)	1 (0.1)
Shetland Sheepdog	1 (0.1)
Irish Setter	1 (0.1)
English Setter	1 (0.1)
Retriever (Flat Coated)	1 (0.1)
Fox Terrier	1 (0.1)
Irish Wolfhound	1 (0.1)
Mastiff	1 (0.1)
Dalmatian	1 (0.1)
Japanese Akita Inu	1 (0.1)
Deerhound	1 (0.1)
Tibetan Spaniel	1 (0.1)
Retriever (Nova Scotia Duck Tolling)	1 (0.1)
Weimaraner	1 (0.1)
Italian Greyhound	1 (0.1)
Norfolk Terrier	1 (0.1)
Rottweiler	1 (0.1)
Dachshund (Miniature Smooth-Haired)	1 (0.1)
Dachshund (Miniature)	1 (0.1)
Lancashire Heeler	1 (0.1)

Appendix V

Number of consultations for PTC issues per dog identified as a case by the regular expression (311,298).

Number of Consultations for Dental Issues per Dog	Count
1	158,479
2	40,764
3	13,093
4	4,493
5	1,614
6	561
7	201
8	68
9	32
10	15
11	8
12	8
13	1
18	1
Total	311,298