ORIGINAL ARTICLE

WILEY

Retrospective study of 1050 dogs with respiratory symptoms in Japan (2005–2020)

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Funding information
Japan Society for the Promotion of Science, Grant/Award Number: 21K20618

Abstract

Background: Few studies have investigated the incidence of respiratory diseases based on anatomical sites or the relationship between breed and these diseases.

Objective: The objective of this study was to investigate the prevalence of canine respiratory diseases among dogs in Japan, with relationship to the breed.

Methods: We retrospectively reviewed the medical records of dogs with respiratory symptoms and calculated the odds ratio (OR) to evaluate the relationship between breed and disease.

Results: A total of 1050 dogs with respiratory symptoms were included in this study. Miniature dachshunds were the most common breed affected by respiratory diseases. Among tracheobronchial diseases, there was a significant association between some small breeds and tracheobronchial collapse, miniature dachshunds (OR: 4.44, 8.43, 95% confidence interval [CI]: 3.17–6.22, 4.33–16.0) and chronic bronchitis and bronchiectasis. Among nasal diseases, miniature dachshunds (OR: 27.2, 95% CI: 16.8–44.8) and golden retrievers (OR: 21.0, 95% CI: 6.43–69.3) were the most affected by non-infectious rhinitis and nasal aspergillosis, respectively. Brachycephalic obstructive airway syndrome was the most common disease among pharyngeal and laryngeal diseases, with a relationship with breed being found in some brachycephalic breeds, and Pomeranians (OR: 2.7, 95% CI: 1.42–5.17).

Conclusions: Respiratory diseases in dogs are strongly correlated with popular breeds in Japan. Miniature dachshunds, in particular, are associated with many respiratory diseases, which may differ from international reports. Thus, this result may help in the early detection, prevention, treatment, and elucidation of the pathophysiology of canine respiratory diseases.

KEYWORDS
canine, epidemiology, respiratory

1 | INTRODUCTION

Respiratory diseases are a major health problem in dogs. Common causes of nasal disease in dogs include nasal neoplasia, fungal rhinitis, and non-infectious inflammatory rhinitis such as lymphoplasmacytic rhinitis (LPR) (Lobetti, 2009; Tasker et al., 1999; Windsor & Johnson 2006). Brachycephalic obstructive airway syndrome (BOAS) is a disease commonly found in the upper airways and presents with a combination of anatomical abnormalities, such as elongated soft palate and laryngeal collapse (Fasanella et al., 2010). Additionally, nasopharyngeal masses and soft palate hyperplasias not related to BOAS are observed in canine pharyngeal diseases (Billen et al., 2006), and laryngeal paralysis is observed in laryngeal diseases (Broome et al., 2000; MacPhail, 2020). Tracheobronchial collapse or bronchomalacia and chronic bronchitis (CB) are the two most common forms of chronic tracheobronchial disease in dogs (Padrid & Amis, 1992). Lung diseases in dogs include acute diseases such as bacterial and aspiration pneumonia (Dear, 2020; Kogan et al., 2008) and chronic diseases such as primary lung tumours and interstitial lung diseases (Hahn et al., 1996; Reinero, 2019a, 2019b). Additionally, anterior mediastinal tumours, such as thymomas and lymphomas, are common mediastinal diseases (Day, 1997) and pleural effusions, pneumothorax, and diaphragmatic hernias are common in intrathoracic diseases (Padrid, 2000). In turn, these diseases generally cause respiratory disorders.

As mentioned above, there have been numerous studies involving several respiratory diseases; however, few studies are available regarding the incidence of diseases based on the anatomical site involved and their relevance to breed. Additionally, the breeds considered popular differ between Japan and other countries. In the United States, medium-to-large breed dogs, such as Labrador retrievers, French bulldogs, and German shepherd dogs, are the top three most popular dogs (American Kennel Club, 2020), while in Japan, small breed dogs such as poodles (especially toys), Chihuahuas, and miniature dachshunds (MDs) are the most popular (Japan Kennel Club, 2020). Because of differences in popular breeds, there may be differences in the incidence of diseases related to geographic distribution. Some breeds that are popular in Japan may be poorly represented in other countries, and, as a result, those breed-related disease predispositions may be poorly characterized. Consequently, it is necessary to determine the prevalence of respiratory diseases in Japan for comparison with the prevalence in other countries. Respiratory diseases were reported to be the leading causes of death due to disease in Japan, being the fourth leading cause of death in dogs at 0 years of age, and third at 10 years of age, ranking higher from younger to older ages (Anicom Holding Inc., 2017); therefore, accurate diagnosis and treatment are urgently needed.

To this end, the purpose of the present study was to investigate the prevalence of canine respiratory diseases in Japan and their relationship with breed. We hypothesized that popular breeds in Japan, such as Chihuahuas, poodles, and MDs, may be closely associated with various respiratory diseases. We believe these results provide new insights and can be applied to early detection and treatment.

2 | MATERIALS AND METHODS

2.1 | Study design and inclusion criteria

In the present study, we retrospectively evaluated the medical records of dogs with respiratory symptoms or suspected respiratory disease that visited the respiratory department of hospital at the university between 1 April, 2005 and 31 March, 2020. Dogs diagnosed with respiratory diseases and with sufficient medical records were included in this study. The following data were collected from the clinical database: sex, age, breed, and clinical or definitive diagnosis. Dogs with incomplete medical records were excluded from this study.

2.2 | Diagnosis

Respiratory disease was diagnosed by two veterinarians specializing in respiratory medicine. Signalment, history of hearing, and physical examinations were initially performed in all cases. Blood tests included complete blood count, biochemistry, blood gas analysis, and coagulation tests, which were selected based on the symptoms and condition of the patient. Radiographic examinations were performed in two orthogonal views for typical head, neck, and thoracic evaluation. Neoplastic diseases were radiographically evaluated in three orthogonal views. Dynamic diseases were additionally evaluated radiographically during inspiration and expiration. Fluoroscopic examination (cough induction and contrast swallow test) was performed in cases of suspected dynamic disease, such as pharyngeal and tracheal collapse or laryngopharyngeal disease related to swallowing function. In addition, ultrasonography was performed in patients with suspected laryngeal and thoracic diseases. Further investigations included computed tomography, magnetic resonance imaging, nasal endoscopy (antegrade and retrograde), laryngoscopy, bronchoscopy, bronchial brush biopsy, and bronchoalveolar lavage under general anaesthesia or sedation. Based on these examinations, histopathological diagnosis by tissue biopsy or cytological diagnosis by fine-needle aspiration, bronchial brush fluid, and bronchoalveolar lavage fluid were performed for definitive diagnosis; bacterial culture and viral tests (canine respiratory disease panel) were also performed. Neoplastic (malignant and benign), inflammatory (neutrophilic, lymphocytic, etc.), and infectious (bacterial and fungal) disease types were diagnosed definitively based upon cytologic or histopathologic examination. However, if the owner did not wish for the patient to undergo further examinations or histological diagnosis under general anaesthesia or sedation because of the risk of anaesthesia or costs, a clinical diagnosis was made based on the results such as signalment, history, radiographic, and therapeutic response.

For a clinical or definitive diagnosis, sites where respiratory symptoms were mainly observed were anatomically classified into the following eight categories: nasal cavity, pharynx, larynx, trachea/bronchi, lung, mediastinum, thoracic cavity, and unknown. When a dog was

found to have multiple diseases, duplicate cases were considered. BOAS was classified based on the site of the anatomical abnormality, such as the pharynx (e.g., elongated soft palate and pharyngeal collapse), larynx (e.g., laryngeal collapse), and trachea/bronchi (e.g., hypoplastic trachea and tracheal collapse). Therefore, BOAS cases with multiple anatomical sites of involvement were considered as duplicate, triplicate, or quadruplicate cases.

2.3 | Statistical analysis

To obtain data for statistical analysis, the medical records of all dogs that visited the hospital during the previously mentioned period were examined and used as the reference population. The odds ratio (OR) and 95% confidence interval (CI) for each category were calculated to investigate the relationship between breed and respiratory diseases. A lower limit of 95% CI > 1 represented a significantly higher risk of respiratory disease in each breed. All analyses were performed using statistical software (Prism, version 9.00, GraphPad Software, San Diego, CA), and p-values < 0.05 were considered statistically significant.

3 | RESULTS

A total of 1050 dogs with respiratory symptoms or suspected respiratory diseases that were referred to the hospital were included in this study. During the same period, 21,784 dogs that visited all hospital departments were included as the reference population. Of the 1050 dogs, the total number of cases was 1267, including duplicate, triplicate, and quadruplicate cases. Regarding sex, 568 were male (294 castrated), and 482 were female (326 spayed). The median age of the dogs was 115 (range: 3–213) months. In total, 80 purebreds were represented, and 49 were crossbreeds. The most common breeds were MD (18.3%, $n = 192$), followed by Chihuahua (9.0%, $n = 95$), toy poodle (9.0%, $n = 95$), Pomeranian (6.6%, $n = 69$), French bulldog (4.8%, $n = 50$), Yorkshire terrier (4.4%, $n = 46$), Labrador retriever (3.8%, $n = 40$), golden retriever (3.6%, $n = 38$), Shih Tzu (3.5%, $n = 37$), and Shiba Inu (2.9%, $n = 34$). In comparison, among the 21,784 dogs in the reference population, MD (12.3%, $n = 2,683$) was the most common breed, followed by toy poodle (9.1%, $n = 1,976$), Chihuahua (7.0%, $n = 1,514$), Labrador retriever (4.4%, $n = 958$), and Yorkshire terrier (4.2%, $n = 922$).

The details of the respiratory diseases categorized by anatomical classification were as follows: trachea/bronchi (32.8%, $n = 416$), nasal cavity (29.6%, $n = 375$), pharynx (13.5%, $n = 171$), larynx (10.7%, $n = 136$), lung (9.3%, $n = 118$), mediastinum (1.5%, $n = 19$), and thoracic cavity (0.4%, $n = 5$), and the cause was unknown in the remaining cases.

3.1 | Trachea/bronchi

There were a total of 416 cases with tracheobronchial disease, of which 226 were male (129 castrated) and 190 were female (129 spayed). Tracheobronchial collapse and bronchomalacia (51.7%, $n = 215$) were the

most common, followed by CB (34.1%, $n = 142$), bronchiectasis (8.9%, $n = 37$), canine infectious respiratory disease complex (3.4%, $n = 14$), and hypoplastic trachea with BOAS (1.9%, $n = 8$).

The median age of dogs presenting with tracheobronchial collapse and bronchomalacia was 129 (range: 5–213) months, and Chihuahuas (20.5%, $n = 44$), Pomeranians (20.0%, $n = 43$), toy poodles (15.3%, $n = 33$), Yorkshire terriers (10.2%, $n = 22$), and Maltese dogs (4.7%, $n = 10$) were overrepresented, with ORs of 3.52 (95% CI: 2.49–4.91), 8.27 (95% CI: 5.88–11.6), 1.83 (95% CI: 1.26–2.65), 2.62 (95% CI: 1.70–4.05), and 2.00 (95% CI: 1.04–3.67), respectively. The median age of dogs presenting with CB and bronchiectasis was 120 (range: 5–201) and 115 (range: 13–192) months, respectively, with MD being overrepresented for each (38.0%, $n = 54$ and 54.1%, $n = 20$), and ORs were 4.44 (95% CI: 3.17–6.22) and 8.43 (95% CI: 4.33–16.0), respectively. Moreover, for CB, the OR for toy poodles was 2.37 (95% CI: 1.54–3.57). The median ages of dogs presenting with canine infectious respiratory disease complex and hypoplastic trachea were 7.5 (range: 4–27) and 18.5 (range: 7–94) months, respectively, with no association with breed.

3.2 | Nasal cavity

There were 375 cases of nasal disease, most of which were rhinitis (50.1%, $n = 188$) or nasal neoplasia (49.3%, $n = 185$). Of the 375 cases, 221 were male (111 castrated), and 154 were female (114 spayed). In the classification of rhinitis, non-infectious rhinitis (28.0%, $n = 105$), such as LPR, was the most common, followed by periodontal disease (6.7%, $n = 25$), nasal foreign body (6.1%, $n = 23$), aspergillosis (2.4%, $n = 9$), and bacterial rhinitis (1.6%, $n = 6$). The cause could not be identified in the remaining 5.3% of the cases. The median age of dogs presenting with rhinitis was 115.5 (range: 8–206) months for non-infectious rhinitis, 120 (range: 50–171) months for periodontal disease, 87 (range: 10–165) months for foreign body, 93 (range: 60–180) months for aspergillosis, and 101 (range: 50–134) months for bacteria. Non-infectious rhinitis was most common in MDs (78.8%, $n = 78$), followed by periodontal disease (48.0%, $n = 12$), with ORs of 27.2 (95% CI: 16.8–44.8) and 6.60 (95% CI: 3.02–14.0), respectively. In aspergillosis, golden retrievers (44.4%, $n = 4$) were overrepresented, with an OR of 21.0 (95% CI: 6.43–69.3). The median age of the dogs presenting with nasal neoplasia was 130 (range: 14–204) months. Adenocarcinoma (33.0%, $n = 61$) was the most common histopathological classification; however, there were also many tumours of unknown origin. In the breeds, Pembroke Welsh Corgis (9.2%, $n = 17$), golden retrievers (8.6%, $n = 16$), and Shetland sheepdogs (5.4%, $n = 10$) were overrepresented, with ORs of 3.04 (95% CI: 1.87–4.96), 2.51 (95% CI: 1.48–4.17), and 2.53 (95% CI: 1.30–4.66), respectively. No significant association was found between histopathological disease type and breed.

3.3 | Pharynx and larynx

In total, 171 cases of pharyngeal disease and 136 cases of laryngeal disease were evaluated. There were 95 males (40 castrated) and

76 females (40 spayed) with pharyngeal disease and 73 males (37 castrated) and 63 females (41 spayed) with laryngeal disease. BOAS (including stenotic nares, elongated soft palate, and pharyngeal collapse as anatomical abnormalities; 59.6%, $n = 102$) was the most common disease of the pharynx, followed by an elongated soft palate not associated with BOAS (17.0%, $n = 29$), inspiratory paroxysmal dyspnoea (9.4%, $n = 16$), nasopharyngeal foreign body (4.7%, $n = 8$), pharyngeal tumour (4.7%, $n = 8$), pharyngeal collapse (1.2%, $n = 2$), and other diseases. In contrast, the most common laryngeal diseases were BOAS (laryngeal collapse; 45.6%, $n = 62$), laryngeal paralysis (35.3%, $n = 48$), laryngeal collapse not associated with BOAS (8.9%, $n = 12$), laryngitis (5.1%, $n = 7$), and laryngeal tumours (5.1%, $n = 7$). The median age of all dogs presenting with BOAS was 65 (range: 3–165) months, which tended to be younger than other diseases, and French bulldogs (34.2%, $n = 39$) was the most commonly affected breed. The proportion of anatomical abnormalities was 71.1% for elongated soft palate, 54.4% for laryngeal collapse, 36.8% for stenotic nares, and 19.3% for pharyngeal collapse, and 67.5% of the cases had two or more components. Among the cases involving BOAS, French bulldogs, bulldogs, Pekingese dogs, pugs, Boston terriers, and Pomeranians were overrepresented, and the ORs were 18.5 (95% CI: 12.4–27.2), 16.4 (95% CI: 7.56–37.5), 11.6 (95% CI: 5.39–25.9), 9.83 (95% CI: 5.74–16.7), 6.42 (95% CI: 3.00–14.6), and 2.70 (95% CI: 1.42–5.17), respectively. Among pharyngeal diseases, golden retrievers (OR: 4.20, 95% CI: 1.57–11.8) and Labrador retrievers (OR: 3.49, 95% CI: 1.30–9.76) were found to be associated with soft palate hyperplasia, but no breed specificity was found among other diseases. Labrador retrievers (37.5%, $n = 18$) were most affected by laryngeal paralysis, followed by laryngeal diseases, most of which affected medium and large dogs, although MDs (10.4%, $n = 5$) were the third most common breed. The median age of dogs presenting with laryngeal paralysis was 128.5 (range: 8–188) months, among which Labrador retrievers had an OR of 13.3 (95% CI: 7.25–23.5) and golden retrievers had an OR of 3.76 (95% CI: 1.72–8.75), although no significant association was found with the MDs (OR = 0.83).

3.4 | Lung

There were 118 cases of pulmonary disease, of which there were 57 males (27 castrated) and 61 females (41 spayed). This category was dominated by lung masses (46.6%, $n = 55$), pneumonia (42.4%, $n = 50$), and emphysema and lung mineralization. Since lung masses include cases that have not been confirmed by histopathological or cytological examination, lung abscess, inflammatory granulomatous, and lung tumours are possible. Of the 14 cases with a definitive diagnosis of primary lung tumour, adenocarcinoma (71.4%) was the most common, with 25.5% of all lung masses being metastatic lung tumours. The median age of dogs presenting with lung masses was 132 (range: 33–180) months, with the most common breed being MD (18.2%, $n = 10$), although no significant association was found. The causes of pneumonia were categorized as follows: aspiration pneumonia (22.9%, $n = 27$), interstitial lung disease (10.2%, $n = 12$), bronchopneumonia (5.1%,

$n = 6$), and bacterial pneumonia (0.8%, $n = 1$), while the causes of the remaining cases were unknown. The overall median age of dogs presenting with pneumonia was 111.5 (range: 3–182) months, with MDs being the most common breed presenting with aspiration pneumonia (33.3%, $n = 9$), with an OR of 3.57 (95% CI: 1.58–7.71). No significant breed association was found with other pneumonia or lung diseases.

3.5 | Mediastinum and thoracic cavity

There were 19 cases of mediastinal disease, 13 of which were male (eight castrated), and six were female (three spayed). Most cases were anterior mediastinal tumours, such as thymomas, with one case each of pneumomediastinum, foreign body in the oesophagus, and hiatal hernia. There were five cases of intrathoracic disease, one was a castrated male, and four were female (one spayed), of which three were diagnosed with pneumothorax and two with pleural effusion. Neither mediastinal nor thoracic diseases were significantly associated with breed.

4 | DISCUSSION

The results of this study clarify the incidence of respiratory diseases in dogs in Japan and their relationship to specific breeds. Among tracheobronchial diseases, which were the most common respiratory diseases, tracheobronchial collapse or bronchomalacia was the most common, accounting for more than 80% of cases together with CB. One of the reasons why tracheobronchial collapse or bronchomalacia was more common than CB in this study was that many small dogs with frequent tracheobronchial collapse or bronchomalacia were included. Similar to previous reports, this study found a significant association in many small dogs such as Chihuahuas and Pomeranians (Macready et al., 2007). In some cases with tracheobronchial disease included in the study, bronchoscopy and bronchoalveolar lavage could not be performed, and clinical diagnosis was made by radiography and fluoroscopy in these cases. Therefore, cases of tracheobronchial collapse or bronchomalacia may be accompanied by CB.

Rhinitis and neoplasia accounted for most nasal diseases, with similar incidences for each disease. LPR was the most common type of rhinitis, consistent with previous reports (Lobetti, 2009; Tasker et al., 1999). In contrast, aspergillosis was less common than previously reported. Aspergillosis is generally considered a common nasal disease, with an incidence of 7.0%–10.7% in previous studies but 4.8% in this study ((Lobetti, 2009; Tasker et al., 1999). Aspergillosis is more common in dogs with large nasal areas, especially large breeds, and this study also found a significant association with Labrador retrievers (Benitah, 2006; Lobetti, 2009). It is possible that the large number of small dogs in this study affected the incidence. In addition, it is thought that regional differences have an effect, as the research was conducted in one city, and further research in other cities is required. Golden retrievers and Shetland sheepdogs were affected by nasal neoplasia (Rassnick et al., 2006; Tasker et al., 1999) but not Pembroke Welsh

Corgis. Nasal neoplasia is common in mesocephalic and dolichocephalic dogs (Tasker et al., 1999), but previous reports have included a variety of breeds. In addition, Pembroke Welsh Corgis are equally popular breeds in Japan and other countries (American Kennel Club, 2020; Japan Kennel Club, 2020), so it is unclear whether this result was due to breed or region.

BOAS and laryngeal paralysis were the most common pharyngeal and laryngeal diseases, respectively, with results similar to those of previous studies (Broome et al., 2000; Fasanella et al., 2010). BOAS is one of the causes of upper airway obstruction in brachycephalic dogs. This disease's primary anatomical abnormalities include stenotic nares, elongated soft palate, laryngeal collapse, and hypoplastic trachea. Previous studies have reported that an elongated soft palate is the most common anatomical abnormality and that two or more of anatomical abnormalities are often present, as have been found in various brachycephalic breeds, such as pugs and English bulldogs (Fasanella et al., 2010; Torrez & Hunt, 2006). These studies reported results similar to those of the present study. However, apart from dogs generally regarded as brachycephalic, small dogs, such as Chihuahuas and Pomeranians, frequently present with clinical signs and anatomical abnormalities similar to those found in BOAS. In this study, a significant association was found among Pomeranians. Previous studies have reported that BOAS is found in Norwich terriers (Johnson et al., 2013), which are not generally considered brachycephalic. Additionally, BOAS observed in Norwich Terriers did not present with general anatomical abnormalities, such as stenotic nares and elongated soft palate, but rather with everted laryngeal saccules and laryngeal collapse. Therefore, it may differ from the pathological condition observed in general brachycephalic breeds, and a genetic relationship has been suggested. In the present study, the most common anatomical abnormalities in Chihuahuas and Pomeranians were elongated soft palates and laryngeal collapse, which did not show similar trends. However, it is possible that these breeds also have similar pathologies. Therefore, we believe that this new result requires further research regarding the interpretation of BOAS. In addition, the relationship between laryngeal paralysis and Labrador retrievers was similar to that reported in previous studies (Broome et al., 2000).

Lung masses and pneumonia account for most lung diseases, and aspiration pneumonia was the most common type of pneumonia. These results support past reports. In addition, the number of cases of mediastinal and pleural diseases was small, consistent with previous reports (Day, 1997; Padrid, 2000); therefore, it is necessary to accumulate more cases for comparison.

In support of our hypothesis, this study found many associations between breed and respiratory diseases. MDs, in particular, were significantly associated with many diseases, such as CB, bronchiectasis, rhinitis (especially LPR), and aspiration pneumonia. Chronic bronchitis is the major cause of chronic cough in dogs and is also a major cause of bronchiectasis, eosinophilic bronchopneumopathy, and pneumonia (Johnson et al., 2016; Mesquita et al., 2015; Padrid et al., 1990; Rozanski, 2020). Older smaller breed dogs were most affected by CB (Rozanski, 2020), while bronchiectasis was most common in cocker spaniels and miniature poodles (Hawkins et al., 2003; Johnson et al., 2016).

However, there are no reports of MDs being affected. The causes of bronchiectasis in the present study were not identified because of the retrospective nature of the study; however, CB and aspiration pneumonia were found to be significantly associated with MDs, suggesting that they may have caused bronchiectasis. In rhinitis, histopathological diagnosis could not be performed in all cases of non-infectious rhinitis although LPR accounted for most cases. For LPR, there are reports that German shepherd dogs and Yorkshire terriers are overrepresented (Lobetti, 2014; Windsor et al., 2004), although there are few reports of other breeds presenting with rhinitis. LPR is the most recognized cause of rhinitis and is associated with immune responses and allergies (Lobetti, 2009; Tasker et al., 1999; Van Pelt & McKiernan, 1994; Windsor & Johnson, 2006), although its pathology is still unknown. Previous studies have reported several immune response-related disorders, such as immune-mediated haemolytic anaemia and inflammatory colorectal polyps in MDs in Japan (Assenmacher et al., 2019; Ohmi et al., 2012; Tani et al., 2020). Therefore, MDs in Japan are considered to have a genetic predisposition to autoimmune diseases, and it is speculated that LPR may be one such pathological condition. A significant association was found between MDs and aspiration pneumonia, the main causes of which include oesophageal disease, vomiting, neurological disease, and laryngeal disease (Kogan et al., 2008). Previous studies have reported that MDs were overrepresented with megaoesophagus in Japan (Nakagawa et al., 2019). Megaoesophagus in dogs is categorized as congenital or acquired, with acquired causes being idiopathic or secondary to diseases such as myasthenia gravis or hypothyroidism (Haines, 2019; McBrearty et al., 2011). Although myasthenia gravis has been reported to be the main cause of secondary diseases, most cases of canine megaoesophagus are of unknown cause and are therefore considered to be idiopathic. Additionally, a previous study reported that 3.6% of megaoesophagus cases were due to laryngeal paralysis (Haines, 2019). Although no significant associations were found in this study, MDs were the third most common breed that presented with laryngeal paralysis. Megaoesophagus, laryngeal paralysis, and hypothyroidism are associated with neurological abnormalities (Jaggy et al., 1994; Stanley et al., 2010). Although the cause of aspiration pneumonia in MDs has not been investigated in the present study, our results suggest that these diseases may have been obscured.

In the present study, we obtained results that differed from those of previous reports on popular breeds in Japan. According to the number of animals registered by the Japanese Kennel Club, MDs and Pomeranians were the most popular breeds in Japan, and MDs were the most popular from 2000 to 2007 (Japan Kennel Club, 2020). In comparison, dachshunds are also popular in other countries (American Kennel Club, 2020), but there are few reports in previous studies that these breeds were associated with respiratory diseases. Furthermore, the American Kennel Club's registered breeds and previous reports did not classify dachshund as standard, miniature, and kaninhen, and it is undeniable that these differences may affect these results. In addition, the majority of dachshunds in Japan are miniature, and the production of these popular breeds is increasing in Japan; therefore, it is thought that the increase in individuals with similar genetic backgrounds may have contributed to these results. There have been reports of

multiple diseases that commonly occur in MDs in Japan (Ohmi et al., 2012; Tani et al., 2020), and these diseases were suspected of having a genetic background. Therefore, further comparisons with the frequency of occurrence in other countries are needed to investigate whether the associations between these breeds and the disease are related to breed, regionality, or genetics.

One limitation of the present study was that, in some cases, patients were clinically diagnosed without tests using general anaesthesia or sedation because of the risk of general anaesthesia or sedation. The owners did not agree to further investigation. For pneumonia especially, for cases such as those involving interstitial lung disease, bronchoalveolar lavage and tissue biopsy could not be performed in all cases. Many cases were diagnosed by combining examination findings, such as radiography and ultrasonography, with symptoms such as clinical signs, duration, and therapeutic response. Another limitation is that our hospital at the university does not provide emergency medical care, and all cases were consulted at a referral hospital asking for a second opinion. Therefore, the number of cases of acute diseases, such as pulmonary oedema and bacterial pneumonia, is small, and those of chronic diseases, such as tumours and rhinitis, may have increased. Additionally, dogs with respiratory diseases without clinical signs may have been present in other departments, which may have led to underestimation of the incidence. Finally, since the diagnosis was made by two veterinarians specializing in respiratory medicine, it cannot be denied that the diagnostic method was not unified.

In conclusion, this study revealed the incidence of respiratory disease in dogs and found a significant association between popular breeds in Japan and respiratory disease, supporting our hypothesis. However, further research is needed to clarify whether these results are related to regional characteristics, such as differences between popular breeds in Japan and other countries, or whether they are related only to breeds in Japan, such as genetic relationships. In addition, since immunological abnormalities and genetic backgrounds have been reported in certain breeds (Assenmacher et al., 2019; Ohmi et al., 2012; Tani et al., 2020), discovering the specificity of the breeds is considered as potential early detection and a first step in understanding the pathophysiology. Furthermore, we believe that elucidation of its pathophysiology may lead to development of new treatments. In the future, we would like to investigate further the genetic relationship between popular breeds and respiratory diseases and their relationship with other common diseases.

AUTHOR CONTRIBUTIONS

Yuta Nakazawa contributed to investigation, data curation, formal analysis, and writing-original draft. Takafumi Ohshima and Michio Fujita contributed to investigation. Aki Fujiwara-Igarashi contributed to conceptualization, investigation, project administration, and writing-original draft. All the authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page have been adhered to.

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PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/vms3.983.

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