

A QUESTIONNAIRE-BASED SURVEY OF OWNER-REPORTED ENVIRONMENT AND CARE OF WEST HIGHLAND WHITE TERRIERS WITH OR WITHOUT CANINE IDIOPATHIC PULMONARY FIBROSIS

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ABSTRACT

Canine idiopathic pulmonary fibrosis (CIPF) is a progressive parenchymal lung disease of unknown origin, primarily affecting older West Highland white terriers (WHWTs). The aims of this study were to describe demographic characteristics of a large cohort of WHWTs with CIPF and to investigate potential predictive factors associated with disease occurrence and mortality, using a questionnaire-based survey. Completed surveys were obtained from 457 respondents representing 542 WHWTs, of which 29.7% were reported to suffer from CIPF. Descriptive statistics were used to characterize the population. Univariate and multivariable logistic regression analyses were performed to identify predictive factors associated with CIPF diagnosis and mortality. Median age at diagnosis was 11.6 years (interquartile range: 9.1–13.3). Lung crackles were reported in 87% of affected dogs. At the time of survey completion, 54.9% of CIPF-affected WHWTs were deceased. Median survival time following diagnosis was 1 year (interquartile range: 0.32–2 years), and cause of death was CIPF-related in 77% of cases. After adjustment for confounding factors, increased odds of CIPF were associated with older age, United Kingdom residence, familial history of CIPF, cardiac disease, regular grooming in dedicated facilities, and treatment for external parasites. Conversely, having a pedigree was associated with reduced odds of disease. Among affected dogs, living in homes containing asbestos increased odds of death, whereas cardiac disease and frequent home grooming were associated with reduced odds of mortality. These findings suggest that genetic background, environmental exposures, care-related factors, and comorbid conditions may influence the occurrence and outcome of CIPF in the studied WHWT population.

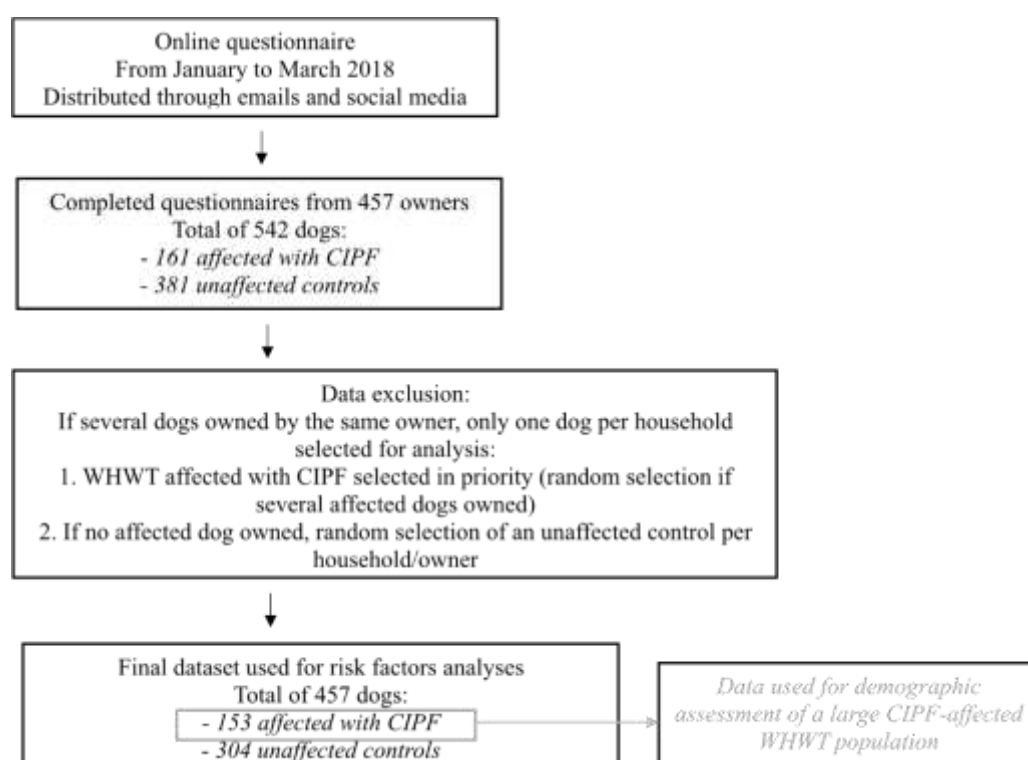
KEYWORDS : DOGS – LUNG – PREDICTIVE FACTORS

Introduction

Canine idiopathic pulmonary fibrosis (CIPF) is a progressive fibrotic lung disease mostly reported in aged dogs of the West Highland white terrier (WHWT) breed. The etiology of CIPF is currently unknown and the pathogenesis is poorly understood (Clercx et al., 2018; Laurila and Rajamäki, 2020). A genetic basis is suspected based on the breed predisposition and the recent identification of two genetic variants associated with CIPF (Piras et al., 2020). Not all dogs of the WHWT breed develop overt CIPF at an advanced age, suggesting that triggering events may be involved in the development and progression of the disease. In humans with idiopathic pulmonary fibrosis (IPF), several occupational (e.g. vapors, gases, fumes, organic and metal dusts) and environmental (e.g. wood dust and air pollution) exposures, lifestyle variables (e.g. smoking and diet), advancing age, viral infection, chronic aspiration of gastric content and genetic factors, have all been associated with an increased risk of disease development (Gandhi et al., 2023). Many of these predisposing factors also appear to act as triggers for acute exacerbations and may thereby contribute to a poor prognosis (Gandhi et al., 2023).

Targeting modifiable environmental and care-related factors in genetically susceptible dogs may provide a cost-effective strategy to reduce CIPF incidence and improve clinical outcomes. Consequently, the aim of this study was to assess the association between selected putative risks and protective factors and CIPF diagnosis and outcome. An additional objective was to describe demographic data of a large cohort of WHWTs affected with CIPF.

Fig. 1. Study decisional flow chart. CIPF = Canine idiopathic pulmonary fibrosis, WHWT = West Highland White Terrier



Materials and methods

QUESTIONNAIRE

A questionnaire-based survey was developed with the assistance of an epidemiologist (CS) and pre-tested to identify and correct any issues prior to the distribution of the final version. The finalized questionnaire was distributed to WHWT owners and breeders via social media and email. It was available online for a three-month period (January to March 2018) and was offered in three languages (French, translated in English and Dutch). The English questionnaire is available as Supplementary data 1.

Before completing the survey, respondents were informed in writing that the investigators were veterinarians conducting research on CIPF, and that the study aimed to collect data from owners of both affected and unaffected WHWTs. Submission of the completed questionnaire was considered to imply informed consent for the use of the provided information for research purposes only.

Demographic data collected from respondents included their country of residence and the number of WHWTs they owned. If multiple dogs were owned, respondents were instructed to complete a separate questionnaire for each dog. Information collected included signalment (sex, neutering status, weight, date of birth), genetic background (pedigree and any known ancestors or relatives affected with CIPF), and medical history (nutrition, vaccination status, deworming, tick/flea treatments, comorbidities, and, if applicable, the date and cause of death (CIPF vs. other cause of death). For WHWTs diagnosed with CIPF, additional disease-related data were collected, including the date of diagnosis, observed clinical signs, and any complementary diagnostic examinations performed.

Environmental and care-related questions included the year of house construction, type of surrounding area, access to compost, presence of home ventilation, air conditioning, or humidification systems, exposure to asbestos, contact with other animals (e.g., birds and rodents), passive smoke exposure, and grooming habits. If the dog had lived in multiple environments during its lifetime, respondents were instructed to provide information based on the environment in which the dog had spent the longest period of its adult life.

STATISTICAL ANALYSIS

All responses were downloaded directly into Microsoft® Excel for Mac (version 2022). Data analysis and modelling were performed using R software (version 4.2.2).

Continuous variables were presented as medians with interquartile ranges (IQR), and categorical variables as numbers and percentages. Descriptive statistics were used to detail the characteristics of the CIPF-affected population. When owners answered “maybe”

to one of the comorbidity categories, it was re-classified as “yes” for the purpose of the statistical analyses to avoid excluding potentially relevant comorbidities.

To avoid bias due to the non-independence of observations within the same household, only one dog per household was included in the predictive factor analysis. A decision chart illustrating the dog selection process is presented in Fig. 1. In households with multiple dogs, preference was given to those diagnosed with CIPF. If more than one affected dog was present, one was randomly selected. The same principle applied to households with multiple unaffected dogs.

Univariate and multivariable logistic regression analyses were used to investigate potential predictive factors for CIPF in WHWTs. Results are presented as crude and adjusted odds ratios (OR) with 95% confidence intervals (95% CI) and their associated p-values. Univariate logistic regression models were first constructed for each potential predictive factor, listed in Table 1. Variables with a p-value < 0.10 in univariate analysis were included in a multivariable logistic regression model. A final model was derived using a backward selection procedure. This final model is considered the most informative, as it accounts for potential confounding factors.

To assess survival among CIPF-affected dogs, a Kaplan-Meier plot was generated. Cox proportional hazards models were used to identify predictive factors associated with mortality following CIPF diagnosis. Results are reported as Hazard Ratios (HR) with 95% CI and their associated p-values. As with the logistic regression analysis, univariate Cox models were first constructed for each predictive factor. Variables with $p < 0.10$ were entered into a multivariable model, with the final model obtained through backward selection.

Missing data (few in most cases) were not replaced, and calculations were always done on the maximum number of data available. Statistical significance was set at $p < 0.05$.

Table 1. List of predictive factors studied according to survey categories.

Survey categories	Predictive factors
Signalment	Sex and neutering status (FI, FN, MI, MN) Age (years) Country of residence (USA, UK, BE, AUS, FR, others)
Genetic background	Known ancestor or relative affected with CIPF (yes or no) Pedigree (yes or no)
Environment	Age of the living habitation (years) Habitation location (city center, peri-urban, rural, other) Access to a compost (yes or no) Air-conditioning/ventilation system in habitation (yes or no) Humidification system in habitation (yes or no) Material containing asbestos in habitation (yes or no) Presence of the dog during house cleaning (yes or no) Passive smoking (yes or no)
Grooming	Grooming in dedicated infrastructures (yes or no) Grooming at home (yes, regularly*; yes, occasionally** or no)
Animal contact	Contact with birds (yes or no) Contact with rodents (yes or no)
Nutrition	Nutrition type (industrial: dry, wet or both, or home-made diet)
Vaccination	Vaccinal status (first vaccinations, every 1 year, or every 3 years)
Prophylaxis	Treatment against internal parasites (no, every 1, 3, 6 or 12 months) Treatment against external parasites (no, every 1, 3, 6 or 12 months)
Comorbidities	Cutaneous (yes or no) Cardiac (yes or no) Digestive (yes or no) Urinary (yes or no) Endocrine (yes or no) Neurological (yes or no) Ophthalmologic (yes or no) Orthopaedic (yes or no) Neoplastic (yes or no)

**Yes, occasionally implied a grooming at home only a few times per year.

FI = female intact; FN = female neutered; MI = male intact; MN = male neutered; USA = United States of America; UK = United Kingdom; BE = Belgium; AUS = Australia; FR = France.

*Yes, regularly implies a grooming at home more than once per month.

Results

DESCRIPTIVE STATISTICS

Completed survey responses were received from 457 respondents owning a total of 542 WHWTs. Most owners were from the United States of America (47%). One hundred sixty-one of five hundred forty-two (29.7%) and 381/542 (70.3%) dogs were classified respectively as CIPF-affected and non-CIPF affected by their owners. The age of 21 dogs was missing. The median age of the remaining 436 dogs was 11 years (IQR: 7–14.1). Two hundred ninety-one of four hundred fifty-six (63.8%) WHWTs had a pedigree. The majority (40.5%) of dogs were neutered females. Most WHWTs (68.4% CIPF-affected and 55.4% nonCIPF

affected) lived in an old (built more than 50 years ago) house and in a peri-urban area. Baseline characteristics of the dogs with and without CIPF are summarized in Table 2.

Median age at the time of CIPF diagnosis was 11.6 years (IQR: 9.1–13.3). Symptoms of CIPF were missing in five dogs. Cough was described in 117/148 (79%), dyspnoea in 80/148 (54%), panting in 77/148 (52%), exercise intolerance in 68/148 (45.9%), syncope in 16/148 (10.8%) and cyanosis in 7/148 (4.7%) of dogs. Crackles were reported on lung auscultation in 120/138 (87%, data were missing in two cases and 13 owners answered “unknown”). Thoracic computed tomography (CT) was performed in 31/90 (34.4%, 46 missing data and 17 “unknown”) of CIPF-affected dogs. Thoracic radiographs were taken in 39/59 (66.1%, one “unknown”) of cases that did not undergo thoracic CT. Echocardiography was performed in 62/114 (54.4%, 27 missing data and 12 “unknown”) dogs.

PREDICTIVE FACTORS ASSOCIATED WITH CIPF

The results of the univariate and final logistic regression analyses are summarized in Table 3. In the univariate analyses, nine possible predictive factors for CIPF were identified, whereas four variables were associated with lower odds of CIPF. No significant association was found between passive smoking and the presence of CIPF in the study population.

After adjustment for country of origin, pedigree status, age, known family history of CIPF, age of residence, presence of air ventilation or humidification systems, grooming practices, antiparasitic treatment, and comorbidities (cardiac, urinary, and ophthalmologic), and following backward model selection, the final multivariable logistic regression model identified six variables (UK origin, increasing age, family history of CIPF, grooming in dedicated facilities, external parasites prophylaxis, cardiac disease) independently associated with increased odds of CIPF and one variable (pedigree) associated with decreased odds of CIPF.

SURVIVAL ANALYSIS

The median survival time for the 153 dogs diagnosed with CIPF was 1.0 year (IQR: 0.32–2.0 years). Among these, 84 (54.9%) were deceased, 55 (36%) were alive and data were missing for 14 (9.1%) at the time of the questionnaire completion. Of the reported deaths, 65 out of 84 (77.4%) were attributed to CIPF. Fig. 2 illustrates the overall survival probability for time to death of CIPF-affected WHWTs.

To identify prognostic factors associated with mortality in dogs affected by CIPF, Cox proportional hazards regression analyses were performed. In univariate analyses, two factors were associated with an increased hazard of death, whereas four factors were associated with a reduced hazard of death. In the final multivariable Cox model, residence in a home containing asbestos remained significantly associated with a higher hazard of

death, whereas regular grooming at home more than once a month and cardiac disease were retained as independent protective factors. Detailed results are presented in Table 4.

Discussion

This is the largest international study to date reporting demographic data on a substantial cohort of healthy and CIPF-affected WHWTs, and investigating factors associated with both the occurrence of CIPF and CIPF-related mortality. The results suggest that genetic background and care-related factors may contribute to the development of CIPF, whereas environmental and care-related variables, rather than genetics, may have influenced disease outcome in this study sample.

A genetic basis for CIPF is suspected based on the strong breed predisposition and the identification of two genetic variants associated with the disease (Piras et al., 2020). Consistent with this, WHWTs with a relative affected by CIPF were more likely to develop this condition in the present study. Interestingly, after adjusting for confounding factors, dogs with a pedigree had lower odds of CIPF compared with non-pedigree WHWTs. It could be hypothesized that this apparent protective effect may reflect the influence of appropriate selection and responsible breeding programs. The popularity of the WHWT breed in the UK, its native country, has decreased in the last 20 years. The reduction in WHWT ownership may have relieved the pressure on breeders to breed from less healthy individuals to meet demand, contributing to the apparent protective effect of pedigree against CIPF, as also hypothesized by other authors regarding the lower-than-anticipated level of skin disorders in WHWTs (O'Neill et al., 2019).

It is important to note that not all WHWTs develop CIPF (Laurila and Rajamaki, 2020). In human IPF, recent evidence indicates that individuals with both a high genetic risk and an unfavourable lifestyle exhibit the highest disease incidence, suggesting a significant synergic effect of these two parameters on disease pathogenesis (Ma et al., 2023). A similar interaction is likely relevant in dogs.

Lifestyle factors incriminated in human IPF are, among others, smoking and diet (Gandhi et al., 2023). Surprisingly, although both direct and second-hand cigarette smoke exposures are among the most well-established risk factors for IPF in humans (Bae et al., 2022; Bellou et al., 2021), passive smoking was not significantly associated with CIPF in this study sample. The relevant questionnaire item was straightforward, suggesting that misunderstanding is unlikely. However, some respondents may have chosen not to answer honestly. It is also possible that smokers did not usually smoke inside, but outside and far from their dog, explaining this discrepancy.

Various occupational and environmental exposures have been linked to increased IPF risk in humans (Gandhi et al., 2023). WHWTs living in the UK had significantly higher odds of developing CIPF. Possible explanations include climatic or environmental differences, higher diagnostic capacity and disease awareness among veterinarians, greater insurance coverage allowing access

to advanced care, and the popularity (although decreasing) of the WHWT breed in the UK. Genetic differences between UK and non-UK dogs may also contribute to this observation.

In the present study, several care-related factors were associated with increased odds of a CIPF diagnosis. While regular grooming at home tended to be protective in the univariate analysis, this association did not persist in the multivariable model. In contrast, regular grooming in dedicated facilities was identified as a significant predictive factor for CIPF, including in the final model. It is plausible that some products used in these settings, such as coat detangling or shining sprays, disinfectants, perfumes and talc-based powders, may trigger the onset or progression of CIPF. There is substantial evidence linking talc inhalation to pleural and pulmonary fibrosis in humans (Johnson, 2021). Subtle respiratory signs could also have been unmasked by the stress of grooming in an unusual environment and noticed by the staff, indirectly leading to veterinary consultation and earlier CIPF diagnosis.

Dogs receiving regular treatment for external parasites had higher odds of CIPF. One possible explanation is that owners who administer frequent prophylactic antiparasitic treatments may be more vigilant to their dogs' health and more likely to consult veterinarians, thereby facilitating earlier or more sensitive CIPF detection. However, treatment against internal parasites did not show a significant effect. The existing veterinary literature provides no evidence for a direct connection between CIPF and commonly used external antiparasitic compounds. Nevertheless, imidacloprid has been implicated in lung injury and impaired pulmonary function in both animal and human studies (Hernandez et al., 2008; Pandit et al., 2016; Xie et al., 2024), and fipronil has demonstrated significant cardiopulmonary toxicity, including oxidative damage and tissue inflammation with mainly irreversible pulmonary changes, in Japanese quail (Khalil et al., 2019). Taken together, current scientific data linking external antiparasitic agents with chronic respiratory disease are limited and of low evidential strength.

As expected, the likelihood of CIPF increased with age in this study sample. In humans, aging is the most prominent factor associated with a higher risk of IPF (Gandhi et al., 2023). In the present study, WHWTs suffering from a cardiac condition had higher odds of CIPF. The risk of both CIPF and cardiac diseases, such as mitral valve disease, increases with age, particularly in small-breed dogs. However, our model was adjusted to account for age as a potential confounding factor. Another possible explanation is that dogs with preexisting (left) heart disease underwent more frequent veterinary follow-up, allowing for earlier or more sensitive CIPF detection through careful lung auscultation or the appearance of echocardiographic signs of pulmonary hypertension (PH). Indeed, PH is a frequent complication of IPF in both dogs and humans (Castria et al., 2012; Roels et al., 2021). Additionally, some dogs initially diagnosed with CIPF may have been subsequently diagnosed with a heart condition (direct consequence of PH versus comorbidity) while undergoing echocardiography for the evaluation of PH.

Conversely, dogs with CIPF and concurrent heart disease had lower odds of death in the survival analysis. This effect may reflect improved medical follow-up and appropriate management, including treatment of PH, in dogs with both conditions. Indeed, Cardillo et al. found a potential survival benefit when pulmonary vasodilator therapy was administered in combination with

antifibrotic medication in patients with IPF and PH (Cardillo et al., 2025). Sildenafil also mitigated the progression of PH specific echocardiographic parameters in a group of WHWTs with CIPF (Roels et al., 2024). Among WHWTs affected with CIPF, regular grooming at home was associated with reduced odds of death, although the underlying reason for this observation remains

unclear. In contrast, dogs living in homes containing asbestos had increased odds of death. Asbestos is a naturally occurring group of mineral silicate fibers known to cause pulmonary and pleural fibrosis, as well as lung cancer, in humans (Gandhi et al., 2023). It is possible that, in the studied cohort, exposure to asbestos contributed to the worsening or to episodes of acute exacerbation of CIPF, thereby leading to a poorer prognosis. However, it is impossible to know whether the respondents who answered negatively to the asbestos-related question were absolutely certain of the absence of asbestos in their house. Including a supplementary "I don't know" option in the questionnaire would have been more appropriate. Consequently, the results related to this question should be interpreted with caution.

It must be acknowledged that the practical actionability of the identified associations is limited. Indeed, several factors are inherently non-modifiable and cannot serve as targets for preventive intervention and, while asbestos exposure, grooming practices, and antiparasitic treatments are theoretically modifiable, the nature and direction of these associations warrant cautious interpretation before any clinical recommendations can be made.

The present study has several limitations, mainly inherent to its survey design. Surveys rely on self-reported data which are prone to biases (e.g. social desirability bias, recall bias, response biases). Low response rates can also impact the representativeness of the sample. Additionally, surveys can lack depth and nuance, and standardized questions may not capture the full spectrum of opinions or experiences. Regarding the classification of responses, "maybe" answers in the comorbidities section were intentionally re-classified as "yes", which may have led to an overestimation of the true prevalence of the various comorbidities. Conversely, the prevalence of comorbidities among English-speaking respondents may have been underestimated due to a translation error in which "e.g." was inadvertently replaced by "i.e.," thereby restricting each disease category to a single specific condition rather than providing one illustrative example per category, as intended in both the Dutch and French versions of the questionnaire. Only 34.4% of WHWTs reported as having CIPF underwent thoracic CT, and 19/128 (14.8%) dogs did not have any type of thoracic imaging performed. Extensive diagnostic workups were infrequently realized, raising the possibility that some dogs were misclassified as having CIPF. A diagnosis of CIPF should not rely solely on signalment and clinical signs, as other differential diagnoses (e.g., bronchomalacia) are possible.

Finally, the study design cannot establish causality or consequence, and the findings may not be generalizable to the entire WHWT population. Identified potential risk and protective factors should be confirmed by longitudinal studies.

In conclusion, this study highlights the complex interplay of genetics, environmental exposure, and care-related variables in association with CIPF. Several potential predictive factors influencing both disease occurrence and outcome were identified. Unfortunately, most of the identified factors are either non-modifiable or difficult to act upon in practice.

Table 2. Baseline characteristics of all West Highland white terriers (WHWTs) (N = 457), stratified by health status: apparently healthy (n1 = 304) and canine idiopathic pulmonary fibrosis (CIPF)-affected (n2 = 153). The second column reports the number of dogs with non-missing data for each variable

Variables	N non missing	Categories	Number (%) of WHWTs N = 457	Number (%) of WHWTs without CIPF n ₁ = 304	Number (%) of WHWTs with CIPF n ₂ = 153
Country	457	Belgium	30 (6.6%)	23 (7.6%)	7 (4.6%)
		France	58 (12.7%)	35 (11.5%)	23 (15.0%)
		UK	45 (9.8%)	13 (4.3%)	32 (20.9%)
		USA	215 (47.0%)	143 (47.0%)	72 (47.1%)
		Australia	68 (14.9%)	63 (20.7%)	5 (3.3%)
		Other	41 (9.0%)	27 (8.9%)	14 (9.2%)
Pedigree	455	No pedigree	165 (36.3%)	99 (32.8%)	66 (43.1%)
		Pedigree	290 (63.7%)	203 (67.2%)	87 (56.9%)
Sex and neutering status	456	Female entire	34 (7.5%)	22 (7.3%)	12 (7.8%)
		Female Neutered	185 (40.6%)	113 (37.3%)	72 (47.1%)
		Male entire	75 (16.4%)	46 (15.2%)	29 (19.0%)
		Male Neutered	162 (35.5%)	122 (40.3%)	40 (26.1%)
Age (years)	436	Median [Q1- Q3]	11 [7.0–14.1]	9.4 [5.8–12.8]	14 [11.4–15.7]
Known ancestor or relative affected with CIPF	455	No	438 (96.3%)	297 (97.7%)	141 (93.4%)
		Yes	17 (3.7%)	7 (2.3%)	10 (6.6%)
Age of the living habitation (years)	415	[0– 50]	284 (68.4%)	203 (73.3%)	81 (58.7%)
		[50 +]	131 (31.6%)	74 (26.7%)	57 (41.3%)
Living location	456	Urban	61 (13.4%)	38 (12.5%)	23 (15.0%)
		Peri-urban	253 (55.5%)	166 (54.8%)	87 (56.9%)
		Rural	128 (28.1%)	92 (30.4%)	36 (23.5%)
		Other	14 (3.1%)	7 (2.3%)	7 (4.6%)
Access to compost	456	No	338 (74.1%)	227 (74.7%)	111 (73.0%)
		Yes	118 (25.9%)	77 (25.3%)	41 (27.0%)
Air conditioning/ventilation in habitation	457	No	167 (36.5%)	90 (29.6%)	77 (50.3%)
		Yes	290 (63.5%)	214 (70.4%)	76 (49.7%)
Humidification system in habitation	456	No	399 (87.5%)	272 (89.5%)	127 (83.6%)
		Yes	57 (12.5%)	32 (10.5%)	25 (16.4%)
Material containing asbestos in habitation	457	No	428 (93.7%)	283 (93.1%)	145 (94.8%)
		Yes	29 (6.3%)	21 (6.9%)	8 (5.2%)
Passive smoking	454	No	414 (91.2%)	277 (91.7%)	137 (90.1%)
		Yes	40 (8.8%)	25 (8.3%)	15 (9.9%)
Presence of dog during house cleaning	455	No	54 (11.9%)	31 (10.3%)	23 (15.0%)
		Yes	401 (88.1%)	271 (89.7%)	130 (85.0%)
Grooming in dedicated infrastructures	457	No	110 (24.2%)	90 (29.7%)	20 (13.2%)
		Yes	344 (75.8%)	213 (70.3%)	131 (86.8%)
Grooming at home	451	No	105 (23.3%)	64 (21.3%)	41 (27.2%)
		Yes, occasionally**	127 (28.2%)	78 (26.0%)	49 (32.5%)
		Yes, regularly*	219 (48.6%)	158 (52.7%)	61 (40.4%)
Contact with birds	455	No	342 (75.2%)	229 (75.8%)	113 (73.9%)
		Yes	113 (24.8%)	73 (24.2%)	40 (26.1%)
Contact with rodents	453	No	362 (79.9%)	243 (80.7%)	119 (78.3%)
		Yes	91 (20.1%)	58 (19.3%)	33 (21.7%)
Nutrition	450	Homemade diet	55 (12.2%)	37 (12.4%)	18 (11.9%)
		Industrial, dry	252 (56.0%)	171 (57.2%)	81 (53.6%)
		Industrial, wet	41 (9.1%)	25 (8.4%)	16 (10.6%)
		Industrial, mix	102 (22.7%)	66 (22.1%)	36 (23.8%)
Vaccinal status	453	Not vaccinated	49 (10.8%)	35 (11.6%)	14 (9.3%)
		Reminder every 3 years	145 (32.0%)	93 (30.8%)	52 (34.4%)
		Reminder annually	259 (57.2%)	174 (57.6%)	85 (56.3%)
Treatment against internal parasites	448	Never	128 (28.6%)	91 (30.0%)	37 (25.5%)

Variables	N non missing	Categories	Number (%) of WHWTs N = 457	Number (%) of WHWTs without CIPF n ₁ = 304	Number (%) of WHWTs with CIPF n ₂ = 153
Treatment against external parasites	451	1 per year	82 (18.3%)	48 (15.8%)	34 (23.4%)
		2 per year	61 (13.6%)	35 (11.6%)	26 (17.9%)
		4 per year	87 (19.4%)	65 (21.5%)	22 (15.2%)
		Monthly	90 (20.1%)	64 (21.1%)	26 (17.9%)
		Never	89 (19.7%)	74 (24.4%)	15 (10.1%)
Dermatological disease	443	1 per year	56 (12.4%)	31 (10.2%)	25 (16.9%)
		2 per year	38 (8.4%)	26 (8.6%)	12 (8.1%)
		4 per year	89 (19.7%)	46 (15.2%)	43 (29.1%)
		Monthly	179 (39.7%)	126 (41.6%)	53 (35.8%)
		No	242 (53.8%)	167 (55.9%)	75 (49.7%)
Cardiac disease	443	Yes	208 (46.2%)	132 (44.1%)	76 (50.3%)
		No	382 (86.2%)	271 (92.2%)	111 (74.5%)
Digestive disease	442	Yes	61 (13.8%)	23 (7.8%)	38 (25.5%)
		No	302 (68.2%)	205 (69.7%)	97 (65.1%)
Urinary disease	442	Yes	141 (31.8%)	89 (30.3%)	52 (34.9%)
		No	406 (91.9%)	275 (93.9%)	131 (87.9%)
Endocrine disease	441	Yes	36 (8.1%)	18 (6.1%)	18 (12.1%)
		No	407 (92.1%)	269 (91.8%)	138 (92.6%)
Neurological disease	444	Yes	35 (7.9%)	24 (8.2%)	11 (7.4%)
		No	427 (96.8%)	282 (96.6%)	145 (97.3%)
Ophthalmologic disease	442	Yes	14 (3.2%)	10 (3.4%)	4 (2.7%)
		No	378 (85.1%)	259 (87.8%)	119 (79.9%)
Orthopaedic disease	438	Yes	66 (14.9%)	36 (12.2%)	30 (20.1%)
		No	329 (74.4%)	223 (75.9%)	106 (71.6%)
Oncology disease	438	Yes	113 (25.6%)	71 (24.1%)	42 (28.4%)
		No	405 (92.5%)	271 (93.4%)	134 (90.5%)
		Yes	33 (7.5%)	19 (6.6%)	14 (9.5%)

*Yes, regularly implies grooming at home more than once per month.

**Yes, occasionally implies grooming at home only a few times per year.

Q1 = first interquartile; Q3 = third interquartile, UK = United Kingdom, USA = United States of America

Table 3. Univariate and final multivariable (after backward selection) logistic regression analyses of factors potentially associated with canine idiopathic pulmonary fibrosis (CIPF). Bold values are statistically significant

		Univariate logistic regression N = 457		Final multivariable logistic regression model (backward models selection) N = 401	
Variables	Categories/Units	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Country	Belgium	Ref.	-	Ref.	-
	France	2.2 (0.82–6.2)	0.13	2.3 (0.60–9.5)	0.24
	United Kingdom	8.1 (2.9–24.9)	< 0.001	12.3 (3.0–58.4)	< 0.001
	United States of America	1.7 (0.71–4.3)	0.27	2.1 (0.63–8.3)	0.24
	Australia	0.26 (0.071–0.90)	0.034	0.34 (0.054–1.9)	0.22
	Other	1.7 (0.60–5.2)	0.33	3.6 (0.85–17.0)	0.091
	Pedigree (Ref=No)	0.64 (0.43–0.96)	0.030	0.52 (0.29–0.93)	< 0.001
Sex and neutering status	Female entire	Ref.	-		
	Female neutered	1.2 (0.55–2.6)	0.69		
	Male entire	1.2 (0.50–2.7)	0.74		
	Male neutered	0.60 (0.28–1.3)	0.21		
Age	Per one-year increase	1.3 (1.2–1.4)	< 0.001	1.3 (1.2–1.4)	< 0.001
Known ancestor with CIPF	Yes (Ref=No)	3.0 (1.1–8.4)	0.029	5.8 (1.3–27.1)	0.021
Age of living habitation	[0– 50] years	Ref.	-		
	[50 +] years	1.9 (1.2 – 2.9)	0.002		
Living location	Urban	Ref.	-		
	Peri-urban	0.87 (0.49–1.6)	0.63		
	Rural	0.65 (0.34–1.2)	0.19		
	Other	1.7 (0.50–5.4)	0.40		
Access to compost	Yes (Ref=No)	1.1 (0.70–1.7)	0.70		
Air ventilation in hab.	Yes (Ref=No)	0.41 (0.28–0.62)	< 0.001		
Humidification system	Yes (Ref=No)	1.7 (0.94–2.9)	0.073		
Asbestos in hab.	Yes (Ref=No)	0.74 (0.30–1.7)	0.49		
Passive smoking	Yes (Ref=No)	1.2 (0.61–2.3)	0.57		
Presence during cleaning	Yes (Ref=No)	0.65 (0.36–1.2)	0.14		
Grooming in dedicated infrastructure	Yes (Ref=No)	2.8 (1.7–4.8)	< 0.001	3.7 (1.8–8.1)	< 0.001
Grooming at home	No	Ref.	-		
	Yes, occasionally	0.98 (0.58–1.7)	0.94		
	Yes, regularly	0.60 (0.37–0.99)	0.043		
Contact with birds	Yes (Ref=No)	1.1 (0.71–1.7)	0.65		
Contact with rodents	Yes (Ref=No)	1.2 (0.71–1.9)	0.54		
Nutrition	Homemade diet	Ref.	-		
	Industrial, dry	0.97 (0.53–1.9)	0.93		
	Industrial, wet	1.3 (0.56–3.1)	0.52		

		Univariate logistic regression N = 457	Final multivariable logistic regression model (backward models selection) N = 401		
Vaccinal status	Industrial, mix	1.1 (0.56–2.3)	0.75		
	Not Vaccinated	Ref.	-		
	Reminder every 3 years	1.4 (0.70–2.9)	0.35		
	Reminder Annually	1.2 (0.63–2.5)	0.56		
Treatment against internal parasites	Never	Ref.	-		
	1 per year	1.7 (0.97–3.1)	0.061		
	2 per year	1.8 (0.97–3.4)	0.063		
	4 per year	0.83 (0.44–1.5)	0.56		
Treatment against external parasites	Monthly	1.0 (0.55–1.8)	0.99		
	Never	Ref.	-		
	1 per year	4.0 (1.9–8.7)	< 0.001	2.6 (0.98–7.4)	0.058
	2 per year	2.3 (0.93–5.5)	0.067	3.3 (1.01–11.1)	0.048
Dermatological disease	4 per year	4.6 (2.4–9.5)	< 0.001	6.0 (2.3–16.9)	< 0.001
	Monthly	2.1 (1.1–4.0)	0.025	2.4 (1.04 – 6.0)	0.046
	Yes (Ref=No)	1.3 (0.87–1.9)	0.21		
	Cardiac disease	Yes (Ref=No)	4.0 (2.3–7.2)	< 0.001	3.1 (1.5–6.6)
Digestive disease	Yes (Ref=No)	1.2 (0.81–1.9)	0.32		
Urinary disease	Yes (Ref=No)	2.1 (1.05–4.2)	0.034		
Endocrine disease	Yes (Ref=No)	0.89 (0.41–1.8)	0.77		
Neurological disease	Yes (Ref=No)	0.78 (0.21–2.4)	0.68		
Ophthalmologic disease	Yes (Ref=No)	1.8 (1.1–3.1)	0.028		
Orthopaedic disease	Yes (Ref=No)	1.2 (0.79–1.9)	0.34		
Oncology disease	Yes (Ref=No)	1.5 (0.71–3.0)	0.28		

Fig. 2. Overall survival probability for time to event (death) of the West Highland white terriers affected with CIPF. The dashed lines represent the 95% confidence interval.

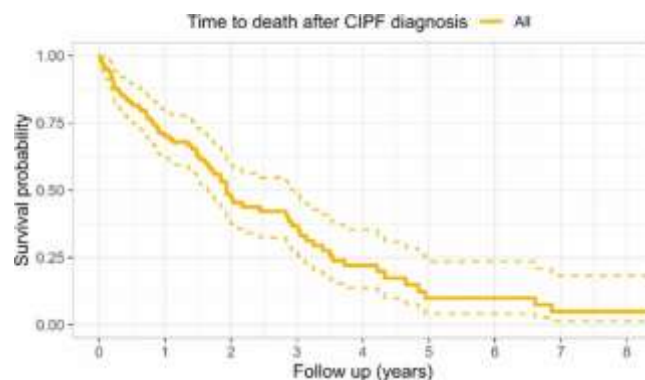


Table 4. Predictive factors associated with survival in the 153 West Highland White terriers affected with canine idiopathic pulmonary fibrosis. Bold values are statistically significant. HR = hazard ratio, USA = United States of America, CI = confidence interval

		Univariate Cox models N = 153		Multivariable Cox model N = 110	
Variables	Categories	Crude HR	p-value	Adjusted HR	p-value
Country	Belgium	Ref.	-		
	France	0.99 (0.32–3.1)	0.99		
	United Kingdom	1.0 (0.34–3.0)	0.98		
	USA	0.87 (0.31–2.5)	0.79		
	Australia	0.54 (0.11–2.5)	0.43		
	Other	0.59 (0.15–2.4)	0.46		
Pedigree	Pedigree (Ref=No)	1.1 (0.68–1.8)	0.70		
Sex and neutering status	Female entire	Ref.	-		
	Female neutered	0.45 (0.20–1.01)	0.050		
	Male entire	0.93 (0.40–2.2)	0.87		
	Male neutered	0.55 (0.23–1.3)	0.17		
Age (years)		1.0 (0.95–1.1)	0.44		
Known ancestor or relative	Yes (Ref=No)	1.4 (0.61 – 3.0)	0.46		
Age of the living habitation	[0,50] years	Ref.	-		
	[50 +] years	1.7 (1.02–2.9)	0.007		
Living location	Urban	Ref.	-		
	Peri-urban	0.94 (0.48–1.8)	0.85		
	Rural	0.94 (0.43–2.1)	0.89		
	Other	0.60 (0.13–2.7)	0.51		
Access to compost	Yes (Ref=No)	0.85 (0.50–1.5)	0.55		
Air conditioning/ventilation in	Yes (Ref=No)	0.71 (0.44–1.1)	0.17		
Humidification system in	Yes (Ref=No)	0.72 (0.37–1.4)	0.35		
Material containing asbestos in	Yes (Ref=No)	3.3 (1.4–7.7)	0.006	6.3 (2.5 – 16.0)	< 0.001
Passive smoking	Yes (Ref=No)	1.0 (0.51–2.1)	0.92		
Presence of dog during house	Yes (Ref=No)	0.65 (0.32–1.3)	0.24		
Grooming in dedicated	Yes (Ref=No)	1.5 (0.61–2.6)	0.55		
	No	Ref.	-	Ref.	-
	Yes, occasionally	0.52 (0.28–0.97)	0.038	0.54 (0.29–1.02)	0.056
	Yes, regularly	0.47 (0.25–0.88)	0.017	0.45 (0.23–0.85)	0.014
Contact with birds	Yes (Ref=No)	1.5 (0.84–2.5)	0.18		
Contact with rodents	Yes (Ref=No)	1.4 (0.77–2.4)	0.29		
Nutrition	Homemade diet	Ref.	-		
	Industrial, dry	1.9 (0.87 – 4.0)	0.11		
	Industrial, wet	0.97 (0.25–3.7)	0.96		
	Industrial, Mix	1.9 (0.79–4.3)	0.16		
Vaccinal status	Not Vaccinated	Ref.	-		
	Reminder every 3 years	0.60 (0.27–1.3)	0.21		
	Reminder annually	0.73 (0.36–1.5)	0.37		
Treatment against internal parasites	Never	Ref.	-		
	1 per year	1.2 (0.60–2.5)	0.58		
	2 per year	0.85 (0.40–1.8)	0.69		
	4 per year	0.93 (0.45 – 2.0)	0.85		
	Monthly	0.78 (0.38–1.6)	0.49		
Treatment against external parasites	Never	Ref.	-		
	1 per year	0.73 (0.28–1.9)	0.52		
	2 per year	0.52 (0.17–1.6)	0.2		
	4 per year	0.710 (0.31–1.6)	0.42		
	Monthly	0.85 (0.38–1.9)	0.69		
Dermatological disease	Yes (Ref=No)	0.57 (0.35–0.93)	0.024		
Cardiac disease	Yes (Ref=No)	0.45 (0.25–0.81)	0.007	0.40 (0.21–0.74)	< 0.001

		Univariate Cox models N = 153	Multivariable Cox model N = 110
Digestive disease	Yes (Ref=No)	0.70 (0.41–1.2)	0.18
Urinary disease	Yes (Ref=No)	0.74 (0.38–1.4)	0.38
Endocrine disease	Yes (Ref=No)	1.0 (0.38–2.9)	0.94
Neurological disease	Yes (Ref=No)	2.1 (0.64–6.6)	0.23
Ophthalmologic disease	Yes (Ref=No)	0.48 (0.24–0.94)	0.031
Orthopaedic disease	Yes (Ref=No)	1.0 (0.57–1.8)	0.97
Oncology disease	Yes (Ref=No)	0.62 (0.30–1.3)	0.19

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Gaëlle Schils: Writing – original draft, Supervision, Formal analysis. **Aline Fastrès:** Validation, Data curation. **Elodie Rizzoli:** Writing – original draft. **Claude Saegerman:** Supervision, Methodology, Formal analysis. **Cécile Clercx:** Validation, Supervision, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Elodie Roels:** Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

ETHICAL APPROVAL

No ethical approval was required for this study, as it consisted of an online questionnaire and did not involve experimental procedures or clinical interventions. Participants voluntarily provided their responses after being informed about the purpose of the study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE MANUSCRIPT PREPARATION PROCESS

During the preparation of this work the authors used ChatGPT in order to support language editing and grammatical consistency. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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APPENDIX A. SUPPORTING INFORMATION

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.tvjl.2026.106705.

DATA AVAILABILITY

The data that assist the results of the study are available from the corresponding author upon reasonable request.

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