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Outcome of appendicular or scapular osteosarcoma treated by limb amputation in cats: 67 cases (1997–2018)

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OBJECTIVE
To evaluate the metastasis rate, survival time, and prognostic factors associated with appendicular or scapular osteosarcoma treated by limb amputation in cats.

ANIMALS
67 cats with histologically confirmed appendicular or scapular osteosarcoma treated by limb amputation.

PROCEDURES
This retrospective cohort study included cats with histologically confirmed appendicular or scapular osteosarcoma between January 1997 and December 2018. A questionnaire survey was conducted at veterinary clinics where limb amputation was performed. Distant metastasis, local recurrence, and lymph node metastasis rates and survival time were determined. Factors associated with distant metastasis and survival were investigated.

RESULTS
The distant metastasis rate after limb amputation was 41.9% (26/62). The overall distant metastasis rate was 46.3% (31/67), including 5 cats with distant metastasis at the time of amputation. Osteosarcoma of the humerus resulted in distant metastasis in 6 of 7 cases. Osteosarcoma of the humerus was significantly associated with distant metastasis in univariate and multivariate analyses (adjusted OR, 9.56). The rate of lymph node metastasis after limb amputation was 3.0% (2/66), and the local recurrence rate was 9.0% (6/67). The median survival time was 527 days. Age and tumor location were not significantly associated with survival time.

CLINICAL RELEVANCE
Distant metastasis occurs in approximately 40% of cats with appendicular or scapular osteosarcoma after limb amputation. In addition, osteosarcoma of the humerus has a particularly high incidence of distant metastasis. Detailed follow-up is therefore necessary, even after limb amputation, especially in cases of osteosarcoma of the humerus.

Feline primary bone tumors are rare, with an incidence of 4.9/10,000 cases.[1] Osteosarcoma is the most common primary bone tumor in cats, accounting for 70% to 80% of all primary bone tumors.[2,3] Although osteosarcoma in cats usually occurs in relatively older cats (8 to 10 years of age), it has been diagnosed in cats with a wide range of ages (1 to 20 years of age).[4–6] Osteosarcoma in cats is generally defined as tumors composed of malignant mesenchymal spindle cells that produce osteoid and is classified as osteosarcoma of medullary origin, parosteal osteosarcoma, fracture-associated osteosarcoma, and extraskeletal osteosarcoma. Osteosarcoma in cats of medullary origin occurs in appendicular or axial skeletal sites, with appendicular osteosarcoma being slightly more common than axial skeletal osteosarcoma.[4,6,7] Appendicular osteosarcoma occurs more often in the hind limbs than forelimbs, and the distal femur, proximal tibia, humerus, and digits are the most commonly affected sites.[6]

Reports from the 1970s to 2000s indicated low metastasis rates of osteosarcoma in cats of 5%, 8%, and 10%, respectively.[3,5,6] In 1974, Liu et al[2] reported that 4 of 5 cats with osteosarcoma treated by limb amputation survived for at least 26 months postoperatively, without recurrence or metastasis. In 1987, Bietto et al[4] reported that 12 cats with appendicular osteosarcoma underwent limb amputation and

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of the 11 available for follow-up, 6 remained alive at the time of the analysis, 13 to 64 months postoperatively. The median survival time of the other 5 cats that died was 49.2 months (range, 1 to 122 months). Only 1 of 11 cats had recurrence, and none developed metastasis. Furthermore, Kessler et al[6] reported that appendicular osteosarcoma in cats had a better prognosis after limb amputation, whereas recurrence was a common cause of euthanasia in cats with osteosarcoma arising in flat and irregular bones. Because of this low metastasis rate, osteosarcoma in cats has been considered to offer long-term survival following amputation alone.[4,6]

However, metastasis of osteosarcoma in cats may not be rare. One study reported fracture-associated osteosarcoma with pulmonary metastasis 3 months after amputation.[8] No large-scale studies have investigated the metastasis rate, prognosis, and associated factors in cats with appendicular or scapular osteosarcoma treated by limb amputation. We hypothesized that the metastasis rate of appendicular or scapular osteosarcoma in cats after amputation was higher than previously reported. Further information on the metastasis rate, prognosis, and associated factors may clarify the need for adjuvant chemotherapy and the importance of follow-up after surgery.

The aim of this study was to investigate the rate of metastasis and survival time of cats with appendicular or scapular osteosarcoma treated by limb amputation. We also explored the predictive factors related to metastasis and survival time.

Materials and Methods

Design

This retrospective cohort study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[9] The study was exempt from approval by the Ethics Committee because it was a retrospective study based on reviews of medical records.

Case selection

We included cats with appendicular or scapular osteosarcoma that had been histologically confirmed at 3 pathology laboratories in Japan (Marupi Lifetech Co, Ltd, North Lab, and IDEXX Laboratories) between January 1997 and December 2018. Hind limb amputation in this study was defined as resection at the hip joint, resection with partial pelvis, or resection at the femur, and forelimb amputation was defined as resection at the shoulder joint, resection with the scapula, or resection at the humerus. Exclusion criteria were extraskeletal osteosarcoma and tumor lesions not confirmed in the bone. The number of cases during the study period determined the sample size.

Outcome measurements

The primary outcome was distant metastasis rate after limb amputation. The secondary outcomes were overall survival time, local recurrence rate, lymph node metastasis rate, and overall distant metastasis rate, including cats with distant metastasis detected at the time of amputation.

Questionnaire methods and variables

Information on breed, age, sex, and tumor location was obtained from the pathology request forms sent by the veterinarians at the veterinary clinics that performed the limb amputation to each pathology laboratory. Questionnaire-based surveys were conducted twice, in 2014 and 2020, respectively. Questionnaires were sent to the veterinary clinic where the limb amputation was performed to obtain information on the prognoses of the cases. Additional information obtained from written questionnaires to veterinarians included body weight; tumor location, the presence of lameness, radiographic abnormalities, and distant metastasis at the time of amputation; use of adjunctive treatments including surgery, radiation, chemotherapy, and NSAIDs; date of tumor recurrence, lymph node metastasis, or distant metastasis and its diagnosis method; and date and cause of death (tumor-related, other cause, or unclear; if the date of death was unclear, we recorded the last day the cat was confirmed to be alive).

Tumor location was classified as the scapula, humerus, radius or ulna, carpus, metacarpus or phalange of forelimb, femur, tibia or fibula, tarsus, metatarsus, or phalange of hind limb, based on the pathology request form, pathology report, and questionnaire. If the pathological examination revealed the location of the bone infiltrated by the tumor, the tumor location was determined from the pathology report; if the pathology report did not reveal the site of the tumor, the tumor location was determined from both the pathology request form and the questionnaire.

Statistical analysis

The local recurrence rate, distant metastasis rate, and lymph node metastasis rate were calculated with 95% CIs. Cases in which the development of metastasis or recurrence was unknown according to the questionnaire were analyzed as no metastasis or no recurrence, to avoid overestimating the respective rates.

Overall survival was determined using Kaplan–Meier survival curves. Overall survival time was defined as the time from amputation to death from any cause. Cats that were lost to follow-up or remained alive were censored at the date of last contact. Cats that died but for which the date of death was unknown were also censored at the date of last contact.

Age and tumor location (humerus or other) were analyzed as variables to identify risk factors associated with distant metastasis and overall survival time.

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On the basis of a meta-analysis report[10] in dogs in which humeral location was a negative prognostic factor for osteosarcoma in dogs in terms of survival time and disease-free interval, we evaluated the tumor location as humerus or other in our study. Cats were placed in 2 groups, below and above the median age, respectively. This analysis included both cases with distant metastasis detected at the time of limb amputation and cases with distant metastasis detected after limb amputation. The association with distant metastasis was determined by univariate analysis using the Fisher exact test and by multivariate analysis using a logistic regression model.

The association with overall survival time was evaluated by univariate analysis using the Log-rank test and multivariate analysis using the Cox proportional hazards model, with the assumption of proportional hazards tested graphically using the Schoenfeld residuals.

Values of $P < 0.05$ were considered statistically significant. All analyses were performed using a statistical software package (Stata, version 13, Stata Corp LLC).

Results

A total of 102 cats were included in this study, of which questionnaires were collected from veterinarians for 74 cats (collection rate, 72.5%). The medical records had been discarded for 7 of the 74 cats because the storage period for the medical records had expired, and no information was therefore available. Sixty-seven cats were therefore finally included in the descriptive and statistical analyses. The characteristics of the cats with osteosarcoma are shown **(Table 1)**, and tumor locations are depicted **(Figure 1)**. Pulmonary metastasis was evaluated by thoracic radiography at the time of limb amputation in 66 cats. Evaluations of local recurrence, lymph node metastasis, and distant metastasis during follow-up after limb amputation were unclear in 9, 40, and 11 cases, respectively. These cases were analyzed as no recurrence or no metastasis to avoid overestimating the respective rates.

Distant metastases at the time of surgery included pulmonary metastasis in 4 cases and bone metastasis in 1 case (5/67 [7.5%]). Lymph node metastasis diagnosed by imaging at the time of surgery was observed in the axillary lymph node in 1 case (1/67 [1.5%]). Six cats received chemotherapy after limb amputation, including carboplatin alone (n = 2), doxorubicin alone (n = 1), combination of carboplatin and doxorubicin (n = 1), and toceranib (n = 2).

The median follow-up time was 324 days (interquartile range [IQR], 151 to 566 days). Local recurrence occurred in 6 cats during follow-up (6/67 [9.0%]; 95% CI, 3.8% to 18.5%), including 5 cases with an amputation site close to the tumor. Two cats with femur osteosarcoma with local recurrence had tumors located in the femoral head, 1 cat with osteosarcoma of the proximal humerus underwent amputation at the shoulder joint, 1 with osteosarcoma of the scapula had recurrence in the muscle at the site of resection, and 1 cat with osteosarcoma of the proximal tibia underwent amputation in the distal third of the femur but developed recurrence at the amputation site. The median time from surgery to local recurrence was 287.5 days (IQR, 250 to 315 days).

Lymph node metastases after limb amputation occurred in 2 cats (2/66 [3.0%]; 95% CI, 0.2% to 11.0%). Superficial cervical lymph node metastasis diagnosed by excisional biopsy was observed 93 days after surgery in 1 cat with osteosarcoma of the proximal humerus, and inguinal lymph node metastasis was diagnosed by imaging in another cat with scapular osteosarcoma at 148 days after surgery.

The rate of distant metastasis after limb amputation was 41.9% (26/62; 95% CI, 30.5% to 54.3%), and the overall distant metastasis rate, including 5 cats with distant metastasis at the time of amputation, was 46.3% (31/67; 95% CI, 34.9% to 58.1%). The sites of metastases in the 26 cats with distant metastasis after amputation (with duplication) were lung (n = 19), bone (n = 4), skin (n = 2), subcutaneous (n = 2), and liver (n = 1). The median time from

Table 1—Characteristics of 67 cats with osteosarcoma.

Characteristic	Value
Median (IQR) age (y)	11 (8–13)
Sex (No. [%])	—
Intact males	5 (7.4)
Castrated males	33 (49.3)
Intact females	6 (9.0)
Spayed females	23 (34.3)
Median (IQR) body weight (kg)	4.5 (3.5–5.3)
Cat breed (No. [%])	—
Mixed breed	53 (79.1)
American Shorthair	6 (9.0)
Norwegian Forest Cat	2 (3.0)
Scottish Fold	1 (1.5)
Unknown	5 (7.4)
Lameness before surgery (No. [%])	60/66 (91)
Radiographic abnormalities before surgery (No. [%])	64/65 (98)

— = Not applicable. IQR = Interquartile range.

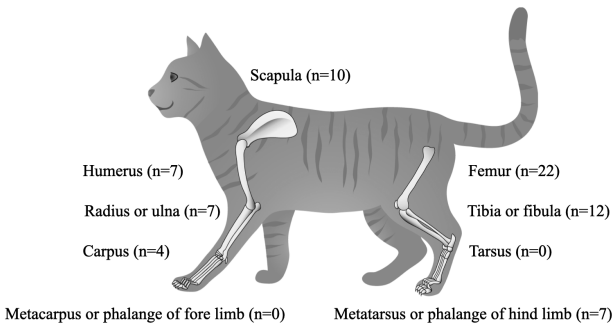


Figure 1—Locations of osteosarcomas in cats. The femur was the most common tumor location. One cat is represented twice because lesions were found in the femur and tibia.

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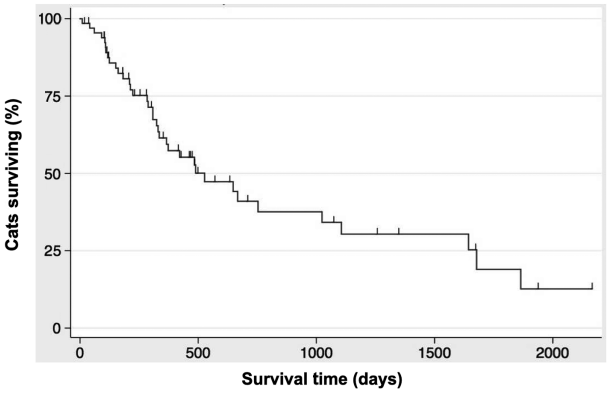


Figure 2—Kaplan-Meier survival curve for 67 cats with osteosarcoma. Survival time was calculated as the number of days from the date of limb amputation to death from any cause. Hash marks represent time of censoring.

surgery to metastasis in these 26 cats with metastasis after amputation was 235 days (IQR, 120 to 265 days).

Age was not associated with the presence of distant metastasis (P = 0.140). However, the presence of distant metastasis was significantly associated with tumor location and was significantly (P = 0.043) more common in cases with osteosarcoma of the humerus (humerus 6/7 [85.7%] vs other 25/60 [41.7%]). Osteosarcoma of the humerus was also associated with distant metastasis in multivariate analysis (adjusted OR, 9.56; P = 0.046).

Regarding the outcomes at the time of analysis, 41 cats had died (41/67 [61.2%]), 14 were still alive (14/67 [20.9%]), and 12 were lost to follow-up (12/67 [17.9%]). Of the 41 cats that died, 5 were censored at the last day of confirmed survival because the date of death was unknown. In addition, 6 of the 12 cats censored because they were lost to follow-up had distant metastases. Six of the 41 cats that died were determined by veterinarians to have died from causes other than osteosarcoma. The median overall survival time was 527 days (IQR, 284 to 1,678 days; **Figure 2**). Neither age nor humeral tumor location was associated with survival time in univariate or multivariate analyses.

Discussion

The present study revealed that distant metastasis occurred in approximately 40% of cats with appendicular or scapular osteosarcoma after limb amputation. In addition, osteosarcoma of the humerus had a high incidence of distant metastasis. To the best of our knowledge, this is the first study to investigate the rate of distant metastasis, survival time, and the associated risk factors in cats with appendicular or scapular osteosarcoma after amputation in the last 2 decades.

With the inclusion of 5 cases that had metastasis at the time of limb amputation, 46.3% of cats with appendicular or scapular osteosarcoma treated by limb amputation developed distant metastasis. In the present study, cases for which the presence or absence of distant metastasis was unknown based on the questionnaire survey were treated as having no distant metastasis to avoid overestimating the distant metastasis rate; however, if the unknown cases were excluded from the analysis, the distant metastasis rate was higher, at 55.4%, indicating that the true incidence of distant metastases may be greater than 46.3%. Detailed follow-up, improved imaging accuracy and diagnostic techniques, and the widespread availability of CT scans may account for the apparently higher rate of distant metastasis detected in this study, compared with previous studies.[3,5,6]

Cats with osteosarcoma of the humerus were more likely to develop distant metastases than cats with osteosarcomas at other sites. Similarly, a meta-analysis in dogs with osteosarcoma also reported that a proximal humeral location was a negative prognostic factor for survival time and disease-free interval,[10] and osteosarcomas of the proximal humerus were associated with poorer metastasis-free survival in humans.[11,12] Osteosarcomas in the proximal humerus may be associated with shorter survival and a shorter disease-free interval in dogs, compared with other sites, because they may be detected at a more advanced stage than tumors at other sites.[10] The current results however indicated that, although a humeral location was associated with distant metastasis, it was not a negative prognostic factor for survival. This apparent discrepancy may be because 3 of the 7 cats with humeral osteosarcomas were censored in the survival analysis because the date of death was unknown, even though 3 of the cases were known to be dead at the time of the survey.

It is necessary to inform the cat's owners that distant metastasis may occur in approximately 40% of cases with appendicular or scapular osteosarcoma treated by limb amputation, with subsequent tumor-related death. Follow-up postamputation imaging examinations are therefore recommended, and postoperative adjuvant chemotherapy should be considered.

This study had some limitations. It was a retrospective multicenter study, and there was therefore no standardized method for diagnosing metastasis and recurrence. In addition, detailed follow-up may not have been performed, because appendicular osteosarcoma has previously been considered to have a good prognosis following amputation alone, leading to assumed low risks of metastasis and recurrence. A second limitation was the lack of information and analysis of histopathologic factors, such as degree of cell differentiation, mitotic index, pleomorphism, and necrosis, as possible predictor variables in this study. Third, there was a possibility of reporting bias. Although we sampled all consecutive cases, only 2/3 of the cases were available for survival analysis. It is possible that facilities with worse outcomes, including metastasis, may have been more likely to answer the questionnaire, in which case the metastasis rate might have been overestimated. However, even if we assume that all 35 cases without questionnaires

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and medical records did not metastasize, the distant metastasis rate would have been 30.4% (31/102), which is still higher than previously reported rates. Further prospective studies are therefore needed, including physical examinations and imaging tests performed at defined intervals, to provide a more accurate diagnosis and follow up the prognosis to confirm metastasis and recurrence.

In conclusion, distant metastasis occurs in approximately 40% of cats with appendicular or scapular osteosarcoma after limb amputation. Furthermore, osteosarcoma of the humerus has the highest risk of distant metastasis. We therefore suggest that detailed follow-up is necessary, even after limb amputation, especially in cats with osteosarcoma of the humerus.

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Ultrasound-guided placement of an anchor wire or injection of methylene blue to aid in the intraoperative localization and excision of peripheral lymph nodes in dogs and cats

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OBJECTIVE
To evaluate ultrasound-guided placement of an anchor wire (AW) or injection of methylene blue (MB) to aid in the intraoperative localization of peripheral lymph nodes in dogs and cats.

ANIMALS
125 dogs and 10 cats with a total of 171 lymphadenectomies.

PROCEDURES
Medical records of dogs and cats that underwent peripheral lymphadenectomies with or without (N) the AW or MB localization technique were reviewed. Data retrieved included clinical, surgical, and histologic findings. The proportions of successful lymphadenectomies, lymph node characteristics, and complications among the 3 groups were analyzed.

RESULTS
143 (84%) lymph nodes were successfully excised. Lymphadenectomy success was significantly affected by the localization technique, with 94% for group AW, 87% for group MB, and 72% for group N. Lymph node size was smaller in groups AW and MB, compared with group N. Duration of lymphadenectomy was shorter in group AW, compared with groups MB and N, and in group MB, compared with group N. Intra- (7%) and postoperative (10%) complications and final diagnosis did not significantly differ among groups.

CONCLUSIONS AND CLINICAL RELEVANCE
Both lymph node localization techniques were highly successful and reduced surgery time, compared with unassisted lymphadenectomy. Specifically, these techniques were effective for localization of normal-sized and nonpalpable lymph nodes and were efficient and practical options for peripheral lymphadenectomies, particularly for those that were small or nonpalpable.

Accurate tumor staging is essential for dogs and cats affected by neoplasia.[1–9] Lymph node evaluation is an important initial step in the management of these patients, provides accurate prognostic information, and helps to guide treatment.[1–9] Many studies[1,3–9] have revealed that lymph node size as assessed by palpation or advanced diagnostic imaging correlates poorly with the presence or absence of tumor metastasis. Cytologic examination of cells aspirated from a lymph node is a readily available, inexpensive diagnostic procedure that has good sensitivity and specificity for detecting neoplastic cell infiltration. However, fine-needle aspiration of a palpable lymph node is easier, compared with aspiration of nonpalpable lymph nodes.[10,11] Despite good sensitivity and specificity, cytologic examination may still yield inaccurate results mainly because of the small amount of aspirated material and the inability to evaluate tissue structure and organization.[3–8,11–13] As such, neoplastic cell infiltration of lymph nodes may not be determinable. Noninvasive techniques for identifying neoplastic cells in lymph nodes, such as contrast-enhanced ultrasonography and CT, sonoelastography, and lymphoscintigraphy, have been investigated, but histologic examination of lymph node tissue remains the most accurate method, especially in cases of micrometastasis.[7,14–17] Sentinel (the first lymph node to which tumor cells are most likely to spread from a primary tumor) or regional lymphadenectomy and histologic examination of the excised lymph nodes allow for identification of overt metastasis, small metastatic aggregates, and micrometastatic foci, especially when examination includes application of

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special and immunohistochemical stains and molecular techniques.[1,4–8,14]

Early detection of lymph node metastasis in people with various cancers is associated with a decreased risk of nodal recurrence and distant metastasis and an earlier start of chemotherapy, thus leading to a survival benefit.[2,5,6] The evidence for this association in dogs and cats is weak, although tumor staging that includes lymph node evaluation is routinely requested by many veterinary oncologists.[1,4–8] Excision of nonpalpable or normal-sized regional lymph nodes can be challenging and may increase surgery time and patient morbidity and lead to extensive surgical dissection and ultimately unsuccessful lymph node localization.[5,6,9] In addition, not all peripheral lymph nodes are readily accessible owing to their anatomic location, their size, or the patient's conformation.[5,9,13] In human medicine, different lymph node localization techniques, such as the use of methylene blue (MB) and anchor wire (AW), for tissue biopsy or lymphadenectomy have been widely implemented.[2,18,19]

MB is a small-molecular-weight dye that is successfully used as a contrast-enhancing agent for the identification of the thoracic duct and for sentinel lymph node mapping in dogs and cats.[20–23] AW localization uses needles that contain a hooked wire and are placed with ultrasound guidance to help to localize nonpalpable breast lesions or deeply located lymph nodes in people.[18,24–26] When the needle is positioned in or near a lymph node, the hooked wire is extruded from the needle and anchored in place to guide the surgeon during lymph node dissection.[24,26] Recently, this technique was used to easily localize inguinal lymph nodes in 4 dogs without perioperative complications.[27]

The objective of the present study was to compare the outcomes of regional lymphadenectomy between the MB and AW lymph node localization techniques and between these techniques and unassisted lymph node localization. The hypotheses were that the use of the MB or AW localization technique would be associated with greater success of lymphadenectomy, compared with unassisted localization; that AW would be associated with greater success of lymphadenectomy, compared with MB; and that the duration of lymphadenectomy and the size of a lymph node associated with the MB or AW localization technique would be less, compared with unassisted localization.

Materials and Methods

Study design and animal eligibility criteria

This retrospective study was approved by the University of Liverpool (protocol No. VREC933) and University of Pisa (protocol No. 48/2019) Research Ethics Committees. The medical records from the University of Liverpool Small Animal Teaching Hospital and Centro Veterinario Dott.ri Pisani-Carli-Chiodo were searched for dogs and cats that had undergone excision of ≥ 1 peripheral lymph nodes between January 2015 and March 2020. Data retrieved included signalment, body condition score (range, 1 to 9), primary tumor histotype, number of excised lymph nodes and their anatomical locations, presence of palpable peripheral lymphadenomegaly (determined through comparison with the contralateral or other lymph nodes), diagnostic imaging used for tumor staging at the time of the initial examination, lymph node diameter determined via diagnostic imaging, duration of preoperative ultrasound, lymph node localization technique, time required for lymph node localization and MB injection or AW placement, any concomitant surgical procedure, duration of lymphadenectomy, results of histologic examination of the excised lymph nodes, intra- and postoperative complications, and any further surgical intervention or medical treatment. Complications were classified as minor, defined as those that did not require additional surgical or medical treatment to resolve, or major, defined as those that required further surgical or medical treatment to resolve. Lymphadenectomy was performed for diagnostic or therapeutic purposes for all animals. The lymph node to be excised was determined on the basis of lymph node size at the time of physical examination, location of the primary tumor, nodal appearance in diagnostic radiographic or ultrasonographic images, previous results of lymph node cytologic examination, results of (sentinel) lymph node mapping by use of lymphangiography, and site of anatomical drainage when lymphangiographic mapping was not performed. Successful lymphadenectomy was defined as accurate lymph node localization and excision as confirmed by histologic examination.

For an animal to be included in this study, each lymph node had to be excised with a separate surgical approach from that for the excision of the primary tumor or the other lymph nodes and had to have a minimal follow-up period of 14 days. For animals that underwent many lymphadenectomies, each lymph node was included as 1 case only if it was from a different lymphoid center. A lymph node was also considered as a new case if lymphadenectomies were performed at other time points because of lymph node changes that were noted during tumor restaging or when another tumor was diagnosed. Animals were excluded if a lymphadenectomy was performed through the same surgical field as another lymph node (ie, lymph nodes were from the same lymphoid center or a ventral approach was used for bilateral cervical lymphadenectomies) or the primary tumor or a lymph node was included in the tissue excised with the primary tumor (eg, limb amputations and radical mastectomies). Popliteal lymphadenectomies were not included in this study because assisted localization was usually unnecessary in our experience.

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Localization techniques

The patients were anesthetized, their hair was clipped, and their skin was aseptically prepared prior to the use of any localization technique; preoperative ultrasonography was performed aseptically approximately 15 minutes before surgery by a board-certified radiologist or an experienced ultrasonographer, with the patient positioned for optimal access to the desired lymph node. Patients were grouped on the basis of the localization technique used as follows.

Group N (unassisted localization)—Unassisted localization and surgeon-requested preoperative ultrasonography were used to determine the size and position of the regional lymph node.

Group MB (localization with MB)—On the basis of a lymph node's location and its depth and on the patient's size and body condition score, 0.1 to 0.5 mL of a 1% aqueous solution of MB was aseptically injected with a 23- to 27-gauge needle and a 1-mL syringe into the lymph node or perinodal tissue with ultrasound guidance. If the surgeon requested, an MB track from the lymph node to the skin was created by depositing approximately 0.01 mL of MB every few millimeters as the needle was removed from the lymph node to serve as a guide for surgical dissection. Animals that had peritumoral MB injection for sentinel lymph node identification were excluded.

Group AW (localization with AW placement)—The ultrasound probe was positioned above the lymph node. With an aseptic technique and ultrasound guidance, a 20-gauge, 70-mm localization needle (IM-IMX, 0IM2007; Biomedical Srl) was passed immediately adjacent to or in a lymph node **(Supplementary Figure S1)**. The point of introduction of the wire guide was agreed to with the surgeon on the basis of the planned surgical approach, or the needle was introduced perpendicular to the skin over the lymph node as close as possible to the intended site of the surgical incision. The beveled needle tip was positioned centrally in or adjacent to the lymph node. The wire component protruded beyond the base of the needle and was used to gently push the hook out of the needle when the needle tip position was satisfactory. The hook was deployed by fixing the needle firmly with one hand and gently advancing the wire with the other hand until a click was audible or palpable or the black mark on the wire was no longer visible, indicating that the AW had been deployed. At that point, the hook wire was anchored in the tissue and could not be retracted. The needle was removed over the wire until the thread extending from the tip of the hook wire was visible on the skin surface. The ultrasound probe was positioned again over the lymph node to verify the correct placement of the AW, and the wire was trimmed approximately 2 cm from the skin at the insertion site.

Surgical approach

After ultrasonography, each patient was transferred to the operating room and skin preparation with an alcohol-based solution was repeated over the surgical field. Lymphadenectomy was performed by an experienced surgeon or by a small animal surgery resident under direct supervision by an experienced surgeon and, where a localization technique was used, the procedure was performed before excision of the primary tumor in all patients in the AW group and in most patients in the MB group. The surgical procedure for each animal in each group was as follows.

Group N—The skin was incised over the lymph node, and a combination of blunt and sharp dissection and electrosurgery was used to identify and excise the lymph node.

Group MB—The skin was incised over the lymph node or where the MB track was visible on the skin. Careful blunt and sharp dissection was used to trace the MB track or to locate the MB stain within the lymph node or perinodal tissue.

Group AW—The skin was incised at the exit site of the wire. A combination of blunt and sharp dissection was used to follow the wire until the lymph node was located.

Once the lymph node was located, the associated vasculature was coagulated or ligated, and without disrupting its capsule, the lymph node was excised. Closure of the surgical site was routine.

Statistical analysis

Statistical analyses were performed with commercially available software (Excel version 14.00 2011 [Microsoft Corp] and SPSS version 26.0 [IBM Corp]). Descriptive statistics were reported for all variables. The Shapiro-Wilk test confirmed that the data were not normally distributed ($P < 0.001$), so the data were reported as median and range. Assessed continuous explanatory variables were age, body weight, lymph node width, and duration of lymphadenectomy. Assessed categorical variables were species, sex, neuter status, body condition score, presence of palpable lymphadenomegaly, occurrence of intra- and postoperative complications, successful lymphadenectomy, and histologic diagnosis (metastatic vs nonmetastatic disease).

A Kruskal-Wallis H test was used to determine whether any significant association existed between the continuous variables and the localization techniques, and a χ^2 test was used to determine whether any significant association existed between the categorical variables and the localization techniques. When a significant association was confirmed, the Fisher exact test for categorical variables and the Mann-Whitney U test for continuous variables were used to characterize the results. Values of $P < 0.05$ were considered significant.

Results

A total of 171 peripheral lymphadenectomies from 125 dogs and 10 cats met the inclusion criteria. Mixed breed (n = 25 [20%]) was the most common

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Table 1—Patient characteristics, physical examination findings, lymph node characteristics, duration of lymphadenectomy, and perioperative complications associated with 171 lymphadenectomies in 125 dogs and 10 cats classified by lymph node localization method, unassisted localization (N), methylene blue (MB) injection, or anchor wire (AW) placement.

Variable	Group N (n = 57)	Group MB (n = 67)	Group AW (n = 47)	*P* value
Species, No. (%)				0.361
Dog	46 (55)	48 (62)	31 (42)	
Cat	2 (2)	4 (5)	4 (5)	
Sex, No. (%)				0.490
Spayed females	24 (21)	32 (28)	17 (12)	
Neutered males	24 (19)	20 (15)	18 (14)	
Age (mo)*	98 (45–168)	108 (27–228)	100 (37–178)	0.167
Body weight (kg)*	22.4 (3.6–48.2)	20.9 (2.6–51.5)	23.3 (3.1–51)	0.130
Body condition score*†	5 (3–8)	6 (3–9)	6 (3–8)	0.319
Large lymph nodes, No. (%)	19 (33)	12 (18)	5 (11)	0.026
Lymph node width (mm)*	8 (3–40)	6 (2.7–30)	5 (2–30)	< 0.001
Duration of lymphadenectomy (min)*‡	32 (15–95)	25 (15–65)	15 (4–35)	< 0.001
Lymph node excision, No. (%)	41 (72)	58 (87)	44 (94)	0.009
Mandibular	18/19 (95)	16/16 (100)	6/6 (100)	
Retropharyngeal	4/6 (67)	5/8 (63)	2/2 (100)	
Prescapular	11/12 (92)	15/16 (94)	3/3 (100)	
Axillary	1/6 (17)	4/6 (67)	7/9 (78)	
Inguinal	7/14 (50)	18/21 (86)	26/27 (96)	
Histologic diagnosis, No. (%)				0.110
Consistent with tumor metastasis	28 (68)	48 (83)	30 (68)	
Consistent with nonmetastatic change	13 (32)	10 (17)	14 (32)	
Complications, No. (%)				
Intraoperative	1 (1.8)	6 (9)	5 (9)	0.153
Postoperative	6 (11)	9 (13)	1 (3)	0.197

*Median (range). †Body condition was scored between 1 and 9. ‡Duration of lymphadenectomy recorded for only 123 (72%) lymphadenectomies.

type of dog and domestic shorthair (7 [70%]) was the most common type of cat. Patient characteristics, physical examination findings, lymph node characteristics, lymph node localization techniques, duration of lymphadenectomy, and perioperative complications are summarized in **Table 1**. Age, body weight, neuter status, sex, species, and body condition score did not significantly differ among the groups.

Lymphadenomegaly was more common in group N than in groups MB ($P = 0.038$) and AW ($P = 0.012$), whereas the frequency of lymphadenomegaly did not significantly differ between groups MB and AW **(Supplementary Table S1)**. All animals but 1 underwent preoperative tumor staging; lymph nodes were evaluated with ultrasonography for 102 (60%) lymphadenectomies and CT for 68 (40%). On the basis of the findings of preoperative diagnostic imaging, target lymph nodes were significantly smaller in group AW, compared with those in groups N ($P = 0.001$) and MB ($P = 0.002$), and in group MB, compared with group N ($P = 0.04$).

Of the 135 animals, 30 (22%) had undergone only lymphadenectomy, whereas 105 (78%) had also undergone another surgery during the same anesthetic period, including cutaneous or subcutaneous mass excision (n = 81), pinnectomy (6), scar excision (3), mandibulectomy (3), thyroidectomy (3), medial iliac lymphadenectomy (3), splenectomy (3), nasal planum excisional biopsy (2), pelvic limb amputation (2), enucleation (1), digit amputation (1), radical mastectomy (1), orchiectomy (1), and arytenoid lateralization (1). Several peripheral lymphadenectomies were performed during the same anesthetic period in 37 (27%) animals. The most common tumor was mast cell tumor (n = 89), followed by melanoma (12), mammary carcinoma (7), thyroid carcinoma (6), soft tissue sarcoma (6), lymphoma (4), adenocarcinoma (3), squamous cell carcinoma (3), plasmacytoma (2), systemic histiocytosis (2), fibrosarcoma (2), hemangiosarcoma (2), and myxosarcoma (1). In 1 dog, granulomatous inflammation was diagnosed.

Histologic examination of 143 lymph nodes revealed the presence of neoplastic cells in 106 (74%), and 56 (53%) of these lymph nodes were of normal size or nonpalpable. Neoplastic cells were not seen in the remaining 37 (26%).

Ultrasound-guided MB injection of or AW placement in each lymph node required < 5 minutes. The median duration for preoperative ultrasonography was 5 minutes (range, 5 to 20 minutes) for the MB group and 6 minutes (range, 5 to 15 minutes) for the AW group. The difference in duration between the 2 groups was not significant ($P = 0.206$).

The AW technique was used for 47 lymphadenectomies. The location of the AW was intranodal in 9 cases and perinodal in 36. In 2 dogs, the AW dislodged during surgery. The MB injection technique was used for 67 lymphadenectomies. The location of the MB was intranodal in 14 cases, perinodal in 32, and not recorded in 21. Duration of lymphadenectomy was recorded for 123 (72%) cases, and the median duration was 25 minutes (range, 4 to 95 minutes).

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Duration of lymphadenectomy was significantly (P < 0.001) shorter for groups AW (median, 15 minutes) and MB (median, 25 minutes), compared with group N (median, 32 minutes), and for group MB, compared with group N (P = 0.026). Antimicrobial and analgesic treatments were prescribed postoperatively at the discretion of the surgeon, and all animals returned to the soft tissue surgery or oncology service by 14 days after surgery for reexamination or follow-up treatment.

Successful lymphadenectomy was achieved in 143 of the 171 (84%) cases, whereas the lymph node could not be located or excised in the remaining 28 (16%) cases; in 1 animal in group N, the mandibular salivary gland was excised instead of the mandibular lymph node. Successful lymphadenectomy was significantly (P = 0.009) affected by the use (vs nonuse) of a localization technique; more lymph nodes in groups MB (58/67 [87%]; P = 0.044) and AW (44/47 [94%]; P = 0.005) were successfully excised than in group N (41/57 [72%]). The success of lymph node localization and lymphadenectomy did not significantly (P = 0.354) differ between groups MB and AW. Among the 3 groups, mandibular lymphadenectomy was the most successful procedure (40/41 [98%]), followed by prescapular (29/31 [94%]), inguinal (51/62 [82%]), and retropharyngeal (11/16 [69%]) lymphadenectomies. Axillary lymphadenectomy was the least successful procedure (12/21 [57%]). The proportions of mandibular and prescapular lymphadenectomies performed successfully were similar among the 3 groups, but proportionally, the AW technique was better for retropharyngeal lymphadenectomy, compared with the MB technique and N, whereas the use of a localization technique was better for axillary and inguinal lymphadenectomies.

Surgery was uncomplicated in 159 of 171 (93%) lymphadenectomies. Twelve intraoperative complications occurred in 11 dogs. One dog in group N had self-limiting hemorrhage during excision of an inguinal lymph node. Lymph node localization was impaired in 6 of 67 (9%) dogs because of leakage of MB into the subcutaneous tissue. In the AW group, 5 complications occurred intraoperatively: 2 AWs dislodged during surgery, but lymph node localization was not affected, and 3 AWs fragmented during excision of 2 axillary lymph nodes in 1 dog and 1 inguinal lymph node in 2 dogs. These 3 AWs could not be retrieved despite the use of radiography and fluoroscopy; the 2 axillary lymph nodes were not localized, whereas the inguinal lymph node was localized. During the follow-up period of 189 days for one of the dogs and 191 days for the other, no further complications were reported.

In the postoperative period, 17 (10%) complications occurred. Sixteen were considered minor and included seroma (n = 9), wound breakdown (4), erythema (2), and cellulitis (1). One complication was considered major: 1 dog had a surgical site infection at the lymphadenectomy site that resolved after antimicrobial treatment. All complications occurred within 14 days after surgery. The median postoperative follow-up time was 115 days (range, 21 to 1,028 days), and follow-up time did not significantly differ among the groups.

Discussion

The results of the present study reveal that both AW and MB techniques were successful for facilitating peripheral lymphadenectomy, and proportionally, success did not significantly differ between these techniques. The American Society of Breast Surgeons suggested that any lymph node localization technique should be ≥ 85% successful.[28] As demonstrated in the present study, both localization techniques were ≥ 85% successful (group MB, 87%; group AW, 94%) and were significantly more successful for regional lymph node localization, compared with unassisted localization (group N, 72%). In addition, use of these techniques significantly reduced the duration of lymphadenectomy, but lymphadenectomy following the AW technique took less time than lymphadenectomy following the MB technique.

The aim of regional lymph node evaluation is to determine the spatial extent of neoplastic disease, thereby helping to guide optimal treatment decisions and possibly influencing prognosis.[17,29] The decision of whether to perform a lymphadenectomy is based on the results of preoperative diagnostic imaging, cytologic examination of cells aspirated from a lymph node, and primary tumor type. Lymphadenectomy can be associated with increased surgery time and patient morbidity and a lack of documented clinical benefit for some tumors.[9]

Fifty percent of normal-sized lymph nodes determined via palpation or nonpalpable lymph nodes that were excised for tumor staging in dogs with mast cell tumors had neoplastic mast cells that were confirmed with histologic examination.[5] Possibly, tumor staging without regional lymphadenectomy and subsequent histologic evaluation would have led to different decisions regarding patient monitoring.[5]

In our experience, excision of nonpalpable and normal-sized lymph nodes (determined through palpation) is a surgical challenge. Excision of these lymph nodes may increase surgery time and morbidity because additional incisions or an extensive approach and more tissue dissection are needed; moreover, lymph node localization may be unsuccessful. Therefore at our institutions, the lymph node localization techniques MB and AW were instituted to overcome this surgical challenge.

MB has been used in various diagnostic and therapeutic procedures because it is generally considered safe, readily available, and inexpensive. However, in people, it may induce a hypersensitivity reaction that ranges from skin rashes to life-threatening anaphylaxis, an intense tissue reaction that may result in skin necrosis when it is injected intradermally,

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a blue discoloration of the operating field, a spurious decrease in intraoperative oxygen saturation of hemoglobin, and permanent skin staining.[9,19,28,30–34] Reported complications for dogs and cats following IV administration of MB includes Heinz body anemia, pseudocyanosis, increased serum alkaline phosphatase activity, and kidney failure.[20,35–43]

In a recent study[35] of the detection and excision of sentinel lymph nodes following peritumoral injection of a radionuclide and MB, no short- or long-term adverse effects were reported; however, MB injection was peritumoral, and the peritumoral tissues were excised with the tumor. Despite the difference in MB techniques between the present and previous studies, no perioperative adverse reactions, including skin necrosis, were noted in either study. Other adverse effects, such as anemia and kidney failure, which often occur within days following MB injection, or granuloma formation, which may occur weeks following MB injection, were also not seen in the present study. Moreover, no differences in postoperative complications were reported between the techniques.

One problem that was encountered with the MB technique in the present study was occasional leakage of MB into the subcutaneous tissue, such that the leakage interfered with the surgeon's ability to identify the lymph node. In these situations, all the stained tissue was excised en bloc. Given the close anatomic relationship of the peripheral lymph nodes with major regional vessels, en bloc resection could result in vascular injury and hemorrhage; therefore, caution is recommended when performing the MB technique. However, vascular injury and hemorrhage were not noted in the affected dogs in the present study.

MB is usually easily visible in the subcutaneous tissue because of its color, so we recommend using a small quantity of MB when injecting it into the perinodal tissue. For deep (vs superficial) lymph nodes, a track of MB from the lymph node to the skin proved helpful in maintaining orientation during surgery and guiding surgical dissection.

Ultrasound-guided AW placement is a well-established, minimally invasive technique adopted in people for the surgical approach of nonpalpable mammary nodules and sentinel axillary lymph nodes; the AW technique has also been used in revision surgeries; foreign body removal; and excision of benign masses, pulmonary nodules, and head and neck lesions (eg, cervical lymph nodes and thyroid tumors).[2,24,25,44–49] This technique was designed to improve the accuracy of resection of a lesion, reduce surgery time, and limit damage to nearby structures[24,25,46,47]; the technique has similar advantages when used for the excision of inguinal lymph nodes in dogs.[27]

The AWs may be deployed within or near to the lesion, depending on the local anatomy and pathologic condition. Therefore, given our experience, the surgeon should be present at the time of ultrasonography to be aware of how the wire is deployed and its position, allowing for improved dissection along the wire tract and adequate lesion resection.[24]

When the AW technique was first used, the aim was to place the AW in the lymph node; however, in many animals, the AWs were found in the perinodal tissue. This may have occurred because of the small size of many of the lymph nodes, AW dislodgement during surgical preparation of the skin after preoperative ultrasonography, or the diagnostic imaging team's lack of experience with placement of AWs. The exact location of the AW was not clinically relevant in the present study because lymph node localization and excision were highly successful. However, feedback from the surgeon following surgery is important to determine whether AW placement in a lymph node is optimal or required.

Wire transection and migration during surgery and damage to vital structures near lesions are well-known complications reported for the AW technique.[49] Intraoperatively, the thin wire may be inadvertently transected such that the removal of the target lesion may be compromised and the wire fragment may be retained in the body, which happened in 1 dog during bilateral axillary lymphadenectomy and in another dog during inguinal lymphadenectomy. The wires had fragmented during dissection, and they could not be retrieved. No complications were reported during the follow-up period for these dogs, but close postoperative monitoring is advised when wire fragmentation occurs.

In people, failure to locate peripheral lymph nodes with the AW technique is associated with age; body mass index; tumor size, location, and grade; type of previous biopsy; and the surgeon's experience.[9] Prospective studies with large sample sizes of dogs and cats are needed to minimize selection bias and to evaluate the potential risk factors for failing to locate lymph nodes with the MB or AW techniques.

The present study was focused on the ability of these techniques to help locate various peripheral lymph nodes, including those that were not sentinel lymph nodes. Sentinel lymph nodes can be the regional lymph nodes but can also be lymph nodes at distant anatomic locations.[14] Various mapping techniques have been developed to localize the sentinel lymph nodes.[4,14,35] The localization techniques evaluated in the present study may be combined with those mapping techniques to guide excision of the sentinel lymph node for accurate tumor staging.

No differences in the proportions of successful lymphadenectomies or complications were noted between the MB and AW groups, but the target lymph nodes were significantly smaller in the AW group, and the duration of lymphadenectomy was significantly less, compared with the MB group. The use of the AW technique significantly reduced surgery time and facilitated the localization of small and nonpalpable lymph nodes.

The main limitation of the present study was its retrospective nature, such that patient management

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varied. Although the patients were followed for a minimum of 14 days after surgery, long-term complications may have been missed. The size of the lymph nodes may have led to a selection bias because the attending clinician may have not elected to use a localization technique for a lymph node that was easily palpable. The techniques were used to localize only 1 lymph node from each lymphoid center, but they may be beneficial for the localization of multiple lymph nodes from the same lymphoid center. Additional studies are needed to assess these techniques' ability to help in identifying multiple lymph nodes from the same lymphoid centers.

In conclusion, ultrasound-guided injection of MB and placement of an AW were safe and accurate techniques to locate various peripheral lymph nodes. The AW technique may be particularly beneficial to reduce surgery time and minimize invasiveness associated with the excision of small or nonpalpable lymph nodes. The AW technique has the potential to become common practice in veterinary surgical oncology.

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Supplementary Materials

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Nonadherence to follow-up recommendations is common for dogs and cats undergoing orthopedic surgery

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OBJECTIVE
To evaluate owner adherence to recommendations for follow-up examination of dogs and cats following orthopedic procedures and identify factors associated with adherence versus nonadherence.

SAMPLE
Medical records of 485 dogs and cats that underwent orthopedic surgery.

PROCEDURES
Cases were categorized as urgent or elective. Information obtained from the medical records consisted of species, age, body weight, proximity to the hospital, procedure cost, recommendations for coaptation, use of financial aid, and number of owners. Cases were considered adherent to follow-up recommendations if, at the latest visit or communication, no further visits were recommended. Cases were considered nonadherent if owners did not return for recommended follow-up visits.

RESULTS
Overall adherence to follow-up recommendations was 65.8% (319/485). Elective cases were 1.6 times as likely to be adherent to follow-up recommendations as were urgent cases, dog cases were 2.4 times as likely to be adherent as were cat cases, and cases with multiple owners listed were 2.1 times as likely to be adherent as were cases with 1 owner listed. Distance from the hospital had a statistically significant association with adherence, but the effect was not clinically important. Age, weight, coaptation, procedure cost, and use of financial aid were not significantly associated with adherence.

CONCLUSIONS AND CLINICAL RELEVANCE
The percentage of dogs and cats lost to follow-up following orthopedic surgery at an academic veterinary teaching hospital was substantial (166/485 [34.2%]). Efforts to improve follow-up adherence are especially indicated for animals undergoing urgent procedures, animals with single owners, and cats.

Postoperative instructions for human and veterinary patients that have undergone orthopedic surgery typically include a recommendation to return for follow-up examinations to monitor recovery and allow for early recognition and treatment of complications. Studies[1,2] of human patients have demonstrated an association between lack of follow-up and poorer clinical outcomes among various patient populations, but to our knowledge, the existence of similar associations for veterinary patients has not yet been investigated. Previous investigators have identified several factors associated with adherence to recommendations for follow-up examinations in human medicine.[3–6] For example, a retrospective study[6] of human orthopedic patients identified tobacco use, living > 100 miles from a medical clinic, and a lack of private insurance as factors associated with follow-up nonadherence. Clinician communication styles and institutional programs can also influence adherence to recommendations, including recommendations for follow-up examination.[7,8]

Adherence to recommendations in veterinary medicine has not been thoroughly described. In a study[9] of dogs that underwent surgery for apocrine gland anal sac adenocarcinoma, overall adherence to staging recommendations was 21% and adherence to treatment recommendations was 34%. A study[8] of general practitioners revealed that 30% of clients adhered to recommendations for dental or surgical treatments for their animals, but adherence was heavily influenced by the way in which the recommendations were communicated by the veterinarian. That study[8] specifically investigated adherence to presurgical recommendations, and to the authors' knowledge, adherence to recommendations for postoperative recheck examinations in companion animals has not been well investigated. However, complete follow-up data seem difficult to obtain for veterinary orthopedic studies,[10,11] and anecdotally, we have observed a concerningly low proportion of orthopedic cases treated at our hospital with a known final outcome.

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The objectives of the study reported here were to determine owner adherence rates to recommendations for follow-up examination of dogs and cats following orthopedic procedures and identify factors associated with adherence versus nonadherence. We hypothesized that cases involving urgent orthopedic procedures would have poorer follow-up adherence, compared with cases involving elective procedures. We also hypothesized that the distance required to travel to the veterinary hospital, initial procedure cost, animal body weight, species, and number of owners would be associated with follow-up adherence versus nonadherence.

Materials and Methods

Case selection and medical records review

Medical records of the University of Florida Small Animal Hospital were searched to identify dogs and cats that had undergone orthopedic surgery between February 2017 and February 2019. All procedures had been performed by a board-certified veterinary surgeon or a resident under the supervision of a board-certified veterinary surgeon. Recommended follow-up times were provided to owners at the time of discharge; however, owners were not obligated to make follow-up appointments. Typically, a veterinary student and house officer (intern or resident) were both responsible for communicating recommendations at the time of hospital discharge. A reminder telephone call by a veterinary technician was made to owners 3 business days prior to any scheduled visits. Owners who were due to return their animal for a follow-up examination but did not make an appointment were typically not contacted.

Cases included in the study were categorized as urgent or elective on the basis of the specific condition treated. Urgent cases included animals with acute (< 2 weeks old) fractures, luxations, and traumatic ligament and tendon injuries. Elective cases included animals treated for elbow dysplasia, hip dysplasia, cranial cruciate ligament rupture, patellar luxation, osteochondritis dissecans, angular limb deformity, and chronic (> 2 weeks old) fractures, luxations, and traumatic ligament and tendon injuries. Additional data collected from medical records consisted of animal age, species, and body weight; number of listed owners; distance between the owners' listed home address and the hospital; initial procedure cost; use of financial assistance (eg, use of the hospital compassion fund or acquisition of a third-party loan); whether mid-term (> 2 weeks) coaptation or bandaging was recommended; follow-up visit recommendations (weeks); and actual follow-up visit times.

Cases were considered adherent to follow-up recommendations if, at the latest visit or communication (by telephone or email), no further visits were recommended. Cases were considered nonadherent to follow-up recommendations if owners did not return with their animal for recommended follow-up visits to the hospital. Cases that were managed postoperatively by another clinic were deemed adherent to follow-up recommendations if medical records specifically indicated that ongoing care would be provided by another veterinary clinic. Cases were also deemed adherent to follow-up recommendations if major treatment recommendations such as revision surgery were declined. That is, a case could have an unsatisfactory outcome but still be deemed adherent to follow-up recommendations. For animals that underwent 2 separate, unrelated procedures > 2 weeks apart, each procedure was considered to be a case, whereas for animals that underwent 2 procedures during the same hospital stay or < 2 weeks apart, all procedures were considered a single case and the procedure that was deemed the most important was defined as the case procedure.

Statistical analysis

Continuous data are summarized as mean ± SD, and percentages of cases classified as adherent versus nonadherent were calculated. Logistic regression was used to assess factors potentially associated with nonadherence to follow-up recommendations. Specific risk factors assessed consisted of procedure type (elective vs urgent), species, age, weight, distance from the hospital, use of coaptation for ≥ 2 weeks, initial procedure cost, use of financial assistance, and number of listed owners. Values of $P < 0.05$ were considered significant. All statistical analyses were performed with standard software (Prism version 8.0; GraphPad).

Results

A total of 485 cases were included in the study. There were 314 (64.7%) elective cases and 171 (35.3%) urgent cases representing 451 (93.0%) dogs and 34 (7.0%) cats. The most common elective procedure was tibial plateau leveling osteotomy (n = 167), and the most common urgent procedure was long bone fracture repair (142). Other elective procedures included medial patellar luxation correction (n = 39), femoral head and neck ostectomy (27), total hip arthroplasty (20), corrective osteotomy for angular limb deformity (13), shoulder arthroscopy (11), tarsal arthrodesis (10), lateral suture stabilization (10), elbow arthroscopy (7), carpal arthrodesis (6), and center of rotation and angulation–based leveling osteotomy (4). Other urgent procedures included mandibular fracture repair (n = 16) and pelvic fracture repair (13). Mean ± SD age at the time of surgery was 4.4 ± 3.6 years (range, 0.3 to 15 years). Mean body weight was 22 ± 16 kg (range, 1 to 79 kg). Mean distance from the hospital was 108.6 ± 137.6 miles (range, 3 to 1,316 miles). Mean initial procedure cost was $3,455 ± 1,558 (range, $1,402 to $22,227). Coaptation for ≥ 2 weeks was recommended in 40 (8.2%) cases. Financial assistance was used in 120 (24.7%)

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Table 1—Results of multivariable logistic regression modeling to identify risk factors associated with adherence to recommendations for follow-up visits for 485 dogs and cats that underwent orthopedic procedures at an academic veterinary teaching hospital.

Variable	OR (95% CI)	*P* value
Procedure type (elective vs urgent)	1.626 (1.027–2.578)	0.04
Species (dog vs cat)	2.423 (1.114–5.311)	0.03
Age (y)	0.9919 (0.9386–1.049)	0.76
Weight (kg)	0.9894 (0.9753–1.004)	0.14
Distance from hospital (miles)	0.9984 (0.9968–0.9998)	0.04
Coaptation for ≥ 2 wk	1.381 (0.6582–3.094)	0.41
Initial procedure cost	0.9999 (0.9998–1.0000)	0.38
Use of financial assistance	0.851 (0.5425–1.344)	0.49
Number of listed owners	2.096 (1.413–3.127)	< 0.01

cases. A single owner was listed for 254 (52.4%) cases, and multiple owners were listed for 231 (47.6%).

Overall adherence to follow-up recommendations was 65.8% (319/485). Of the 166 cases nonadherent to follow-up recommendations, 83 (50%), 60 (36%), 8 (5%), and 7 (4%) missed their first, second, third, and fourth or later follow-up visit, respectively. A higher proportion of elective cases adhered to follow-up recommendations (219/314 [69.7%]), compared with urgent cases (100/171 [58.5%]). Elective cases were 1.6 times as likely to be adherent to follow-up recommendations as were urgent cases **(Table 1)**, dog cases were 2.4 times as likely to be adherent as cat cases, and cases with multiple owners listed were 2.1 times as likely to be adherent as cases with only 1 owner listed. Distance from the hospital had a statistically significant association with adherence to follow-up recommendations; however, the effect size was small (0.1% change in odds per 1-mile increase in distance). Age, weight, use of coaptation for ≥ 2 weeks, initial procedure cost, and use of financial assistance were not significantly associated with adherence to follow-up recommendations.

Discussion

In the present study, the percentage of dogs and cats lost to follow-up following orthopedic surgery at an academic veterinary teaching hospital was substantial (166/485 [34.2%]), and adherence to follow-up recommendations was particularly poor for urgent cases (71/171 [41.5%]). Further, a large percentage of cases designated as nonadherent to follow-up recommendations (83/166 [50%]) did not return for > 1 recommended follow-up visit. We also found that cases with a single owner and cat cases specifically were more likely to be nonadherent. Finally, although there was a statistically significant association between nonadherence and greater distance between listed home address and the hospital, the effect size was clinically insignificant.

In the present study, follow-up adherence was defined simply by whether an animal was returned for a follow-up appointment. We used this criterion because we were mainly interested in the percentage of treated cases with a known outcome. The low rates of follow-up adherence were concerning but not surprising. For instance, it is common for retrospective studies in veterinary orthopedics to exclude large numbers of cases owing to inadequate follow-up.[10] Our rates of nonadherence to follow-up recommendations appeared comparable to those reported for human patients that have undergone orthopedic trauma surgery, for whom follow-up adherence at the first scheduled postoperative recheck appointment has been reported to be 66.9%.[6]

Cases undergoing elective procedures had better follow-up adherence than did cases undergoing urgent procedures in the present study. This was an expected finding and agreed with our hypothesis. It is likely that owners of animals in the urgent and elective groups represented 2 different owner populations. Owners of elective cases may be more financially able to comply with follow-up recommendations, whereas owners of urgent cases may be more representative of a broader owner population. Because elective procedures by definition are not essential, owners have time to research and prepare for the procedure prior to proceeding. The higher follow-up rates for cases ungergoing elective procedures may therefore be a reflection of owners being properly educated and financially prepared for the procedure. For cases considered urgent, owners may have had less time to consider long-term care and associated follow-up costs for the procedure recommended. Urgent cases were associated with trauma, and the nature of those injuries and procedures may have resulted in greater variability in follow-up visits relative to recommendations for elective cases. In addition, clinician-related factors may have played an important role. The manner in which recommendations are made by clinicians can have a profound effect on owner or patient adherence,[8] and it is possible that communication with clients was not as well developed for urgent cases as for elective cases.

In the present study, dog cases were more than twice as likely to have been adherent to follow-up recommendations as were cats. However, cats accounted for only 7% of the study population, which reflected the overall caseload of our referral small animal hospital. Consequently, fear-free environmental adaptations for cats are not featured prominently in our hospital. Stress-related considerations are a well-known deterrent for cats requiring veterinary visits, and practices such as pheromonotherapy and feline-specific examination rooms can reduce stress scores in cats.[12] Whether providing such adaptations and educating owners about their benefits could impact follow-up adherence in cats requires further investigation. In the recent *AVMA Pet Ownership and Demographic Sourcebook*,[13] cats were significantly

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more likely to be considered a companion rather than a family member, compared with dogs, and lower follow-up adherence rates may be reflective of the difference in the animal-owner bond for dogs versus cats.

Cases that had ≥ 2 owners listed were twice as likely in the present study to be adherent to follow-up recommendations as were cases with only a single owner. Reasons for this finding are unclear, but it could have reflected the benefits of having multiple individuals responsible for the care of an animal. For instance, multiple owners may have greater flexibility in their schedules and, thus, be better able to comply with follow-up visits. Additionally, 2 owners may typically have more income, compared with a single owner and may therefore be more financially able to comply with follow-up recommendations and their associated costs. It is important to note that actual owner financial status was unknown in the present study, and no other patterns associated with finances (such as initial cost of the procedure and use of financial assistance) were observed. Furthermore, the number of listed owners may not accurately reflect the number of actual owners, as there are no established rules for capturing all legal owners in our medical record system.

Although distance from hospital had a statistically significant effect on adherence to follow-up recommendations in our study, the effect size was not clinically significant. We therefore rejected the hypothesis that longer travel distances lead to poorer adherence to follow-up recommendations. A study[14] investigating barriers to follow-up after general surgery procedures in people found that increased travel time was associated with a reduced likelihood of adhering to postoperative follow-up recommendations. The lack of association between travel distance and follow-up adherence in our study could be explained by the fact that owners were already willing to travel for the index treatment at our hospital over other more local specialty clinics, and owners who were willing to travel to our facility were not any more averse to returning for follow-up visits. This explanation may also address the lack of association between initial procedure cost and follow-up adherence, in that owners who were willing to pay for more expensive procedures were just as willing to pay for follow-up visits.

Our study did not provide any insight into the benefits of follow-up visits. Follow-up visits were recommended for the purposes of optimizing clinical outcomes by monitoring progress and adjusting therapeutic interventions; however, it is not possible to determine from this study whether nonadherent cases had poorer outcomes than adherent cases. This observation highlights one of the main motivations for conducting the present study: that the effects of our interventions remain unknown without proper follow-up.

The retrospective nature of the present study was a major limitation. Some animals considered lost to follow-up may have still obtained proper postoperative and ongoing care at other veterinary clinics without keeping our hospital informed. The initial procedure cost may not have been reflective of the original financial estimate provided, and the initial estimate (rather than final cost) may have had a stronger influence on whether a client was able to afford follow-up visits. We were not able to investigate the effect of pet insurance, because this information was not available in our medical records system. Unsurprisingly, previous studies[6,15] in human medicine have demonstrated a poorer adherence to follow-up recommendations among individuals who do not have health insurance, and we suspect a similar effect would be apparent for veterinary patients. Importantly, adherence is influenced by both clinician- and client-related factors,[8] and our study design precluded the ability to investigate important clinician-related factors such as the ability to communicate the value of follow-up visits. All cases were treated at a single institution, and our results may not be representative of other types of hospitals. For example, hospitals with stronger ties to referring veterinarians may have fewer cases nonadherent to follow-up recommendations. This may be especially relevant when bandage changes, which are often performed by a local veterinarian, are recommended. Our population was heterogenous, including cases that underwent a wide array of orthopedic procedures, and the sample size was too small to parse out differences in follow-up rates according to anatomic site or surgical procedure.

In conclusion, results of the current study indicated that a large percentage of dogs and cats will be lost to follow-up after orthopedic surgery, and we were able to identify risk factors associated with nonadherence to follow-up recommendations. Future studies should investigate adherence in other veterinary hospitals, such as private practices, and strategies to improve follow-up adherence.

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2022 AVMA

PET OWNERSHIP AND DEMOGRAPHICS SOURCEBOOK



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Veterinary Economics Division
American Veterinary Medical Association
May 2022

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INTRODUCTION

The American Veterinary Medical Association (AVMA) is committed to advancing the science and practice of veterinary medicine, and a key component of that mission is understanding pet populations and ownership. This report provides updated information on pet-owning households, including demographics and behavior information. It analyzes pet owner data through an economic and social lens to better understand who pet owners are, how they behave, and what their impact is on pet populations. In this edition of Pet Owner Trends, readers will find valuable insights on pets and their owners, plus information on the impact of COVID-19 on pet ownership and behaviors, such as adoptions.

This report is based on a survey conducted in early 2021 via online opt-in, reflecting 2020 data. The data were sampled, weighted, and screened to eliminate potential sources of bias and provide accurate estimates and insights. A total of 2,011 respondents completed the online survey and were included in the final analysis reported here; the margin of error is 2.2% within a 95% confidence level.

Both demographic and behavioral characteristics of respondents were compared to the general population for weighting and estimations. Logistic regression and difference in means test were performed to see which characteristics influence whether a household adopted a pet, how likely they were to see a veterinarian, and how likely they were to delay seeing the veterinarian. More information is available in the methodology section.

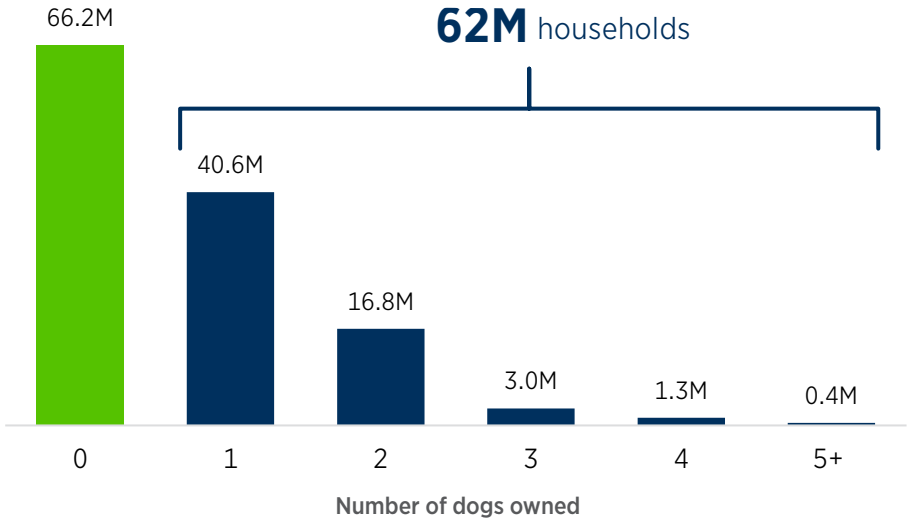
PET POPULATION	
2020	**2016***
83,739,829 – 88,853,254 dogs	**76,811,305** dogs
1.46 dogs per household	**1.6** dogs per household
45% of households own dogs	**38%** of households own dogs
60,217,861 – 61,910,686 cats	**58,385,725** cats
1.78 cats per household	**1.8** cats per household
26% of households own cats	**25%** of households own cats

DOG POPULATION INCREASED BY 6.9 – 12 MILLION*

Dog ownership **increased by 6%** from 38.4% (2016) to 44.6% (2020), although the average number of dogs per household decreased from 1.6 to 1.46 dogs per household. Although the number of dogs within households declined, more households owned dogs and this led to an overall increase in the total population of dogs owned. It's important to note these are estimates based on a sample size of 2,000. Advanced weighting techniques were used to enhance the accuracy of these estimates, and a range is provided for a more accurate representation of population estimates. However, given the total US population of 128 million households in 2020 estimations, projecting pet populations from a limited sample size of 2,000 has difficulties that need to be considered even with the best weighting techniques (see methodology section for additional information).

**All data on pets only include pets as reported by respondents who indicated they own pets. Pets without homes (those in a shelter, store, or feral) are not included in these estimates.*

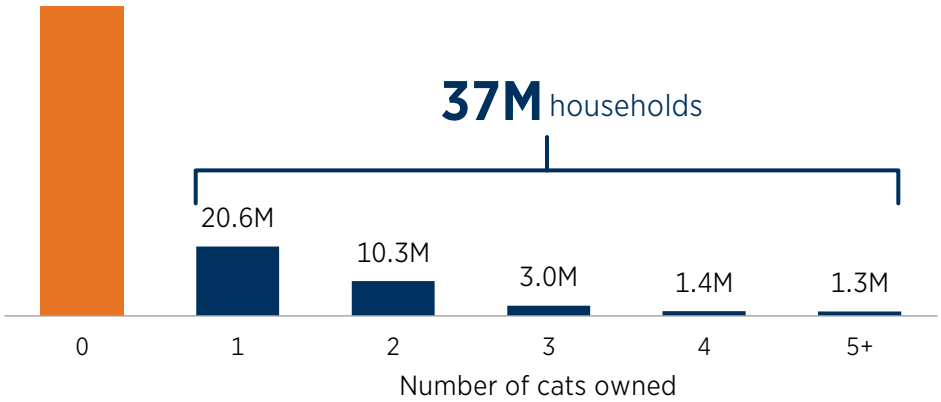
» DOGS PER HOUSEHOLD



CAT POPULATION INCREASED BY 1.8M IN 2020*

The overall owned cat population **approximately 3% each year between 2016 and 2020**, ending the trend of declining cat populations observed in both 2011 and 2016. Cat ownership increased slightly from 25% in 2016 to 26% in 2020, although the number of cats per household decreased slightly from 1.8 to 1.78.

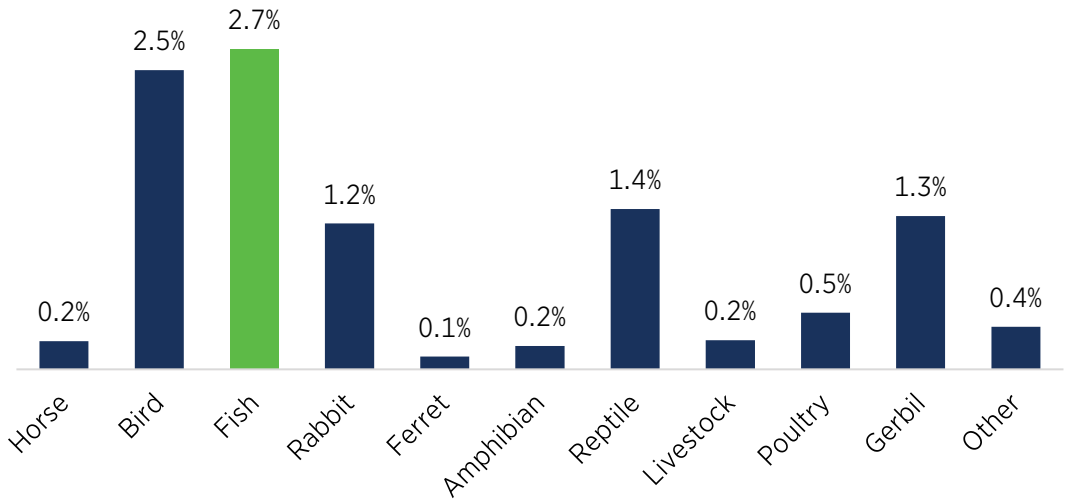
» CATS PER HOUSEHOLD





OTHER PETS

As with previous years, fish continue to be the third most popular pet (2.7%) behind dogs and cats, although 2016 had a much higher rate of ownership at 8.3%. Birds are not far behind at 2.5%. Pet ownership outside of dogs and cats consists of a small population so greater variability in the data is expected.



FUN FACTS – MOST POPULAR PET NAMES

	DOGS	CATS
1	Max	Tom
2	Bella	Tigger
3	Rocky	Bella
4	Daisy	Jack
5	Jack	Tommy
6	Molly	Lilly

» LEVERAGING THESE DATA

- There were increases to both cat and dog populations, and moderate increases in the percentage of households owning dogs or cats.
- The number of dogs and cats per household decreased from 2016, indicating a larger increase in single-pet households.
- Practices might consider targeting services and marketing messaging to new pet owners.
- As the average number of dogs and cats per household decreases, practices may consider expanding their client base to maintain adequate patient caseloads.





EXPENDITURES AND VISITS

» VETERINARY CARE

Veterinary care—as measured by veterinary services delivered plus medication—had an average cost of $326 a year per household, which comprised 33% of total annual spending on household pets. The amount households spent on veterinary care varied by species and the number of animals owned. For example, households with one cat spent an average of $248 a year on veterinary care, while households with two or more dogs spent an average of $391 a year on veterinary care for all household pets. Medications comprised approximately 30% of total dollars spent on veterinary care, making medications an important component of practice revenue.

EXPENDITURES ON VETERINARY CARE

Cost of last visit (per pet)	Households with no spending on veterinary care
Dog owners: **$195**	Dog owners: **11%**
Cat owners: **$162**	Cat owners: **19%**

Veterinary care accounted for the largest proportion of household spending for dog owners at $367 per year, while cat owners spent more on food ($310 per year) than veterinary care ($253).

TOTAL SPENDING ON PETS PER YEAR

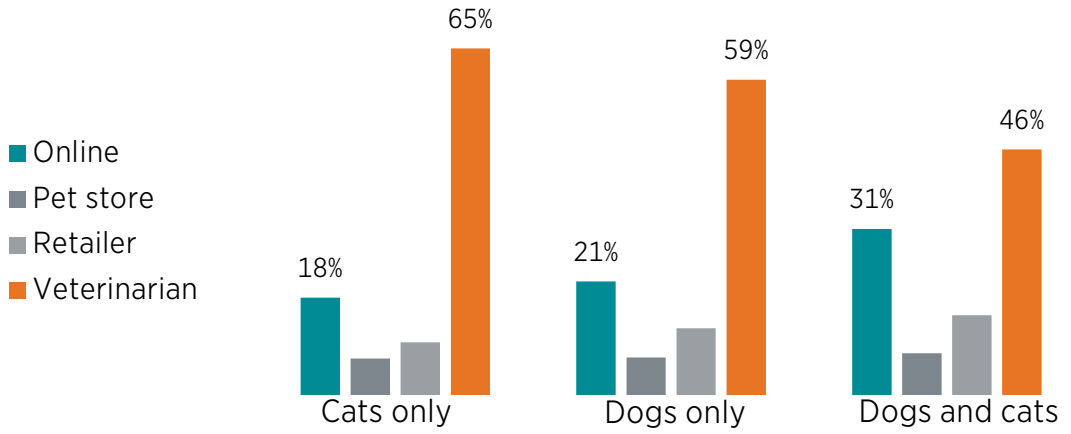
Households with dogs only	Households with cats only	Households with dogs and cats
Food **$339**	Food **$310**	Food **$321**
Veterinary care **$367**	**Veterinary care** **$253**	**Veterinary care** **$311**
Toys **$79**	Toys **$50**	Toys **$83**
Grooming **$99**	Grooming **$18**	Grooming **$64**
Other **$28**	Other **$22**	Other **$28**

VETERINARIANS ARE THE MOST TRUSTED PROVIDERS FOR MEDICATIONS

Most pet owners (46% to 65%) rely on their veterinarian for purchasing medications. This is true for both dog and cat owners. Pet owners with both cats and dogs were the most likely to purchase medications online (31%)*. Pet owners who purchased medications from their veterinarian were most likely to cite **expertise (59%)** as a reason for choosing their veterinarian. Ease of access also was a relatively strong reason for this group (45%). Compared to the other sources, price was the least cited reason for purchasing from the veterinarian (20%). Those who purchased from an online store or retailer were most likely to cite price (54%) or ease of access (57%) as the main reason. Owners who used a pet store (Petco, Petsmart, feed supply, etc.) were most likely to state availability of medication as the main reason (68%).

**Online was described as "Amazon, chewy, or other online."*

» WHERE DO YOU BUY MEDICATIONS?



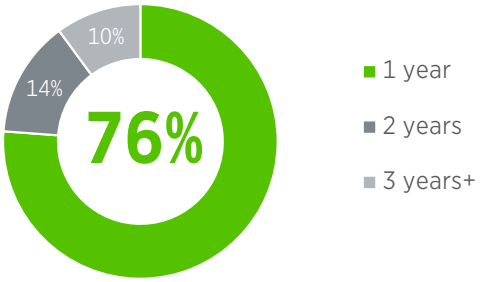
**Online was described as "grocery store, Target, Walmart, or other superstore." Pet store is reported as "Petco, Petsmart, feedstore, etc."*

» REASONS FOR CHOOSING MEDICATION PROVIDER

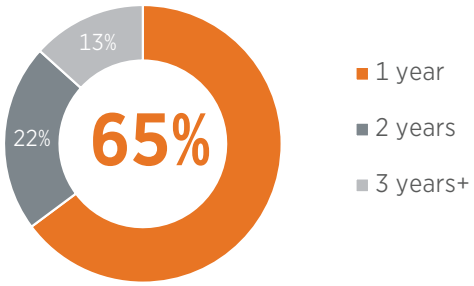




» WHEN WAS THE LAST TIME YOUR DOG SAW A VETERINARIAN?



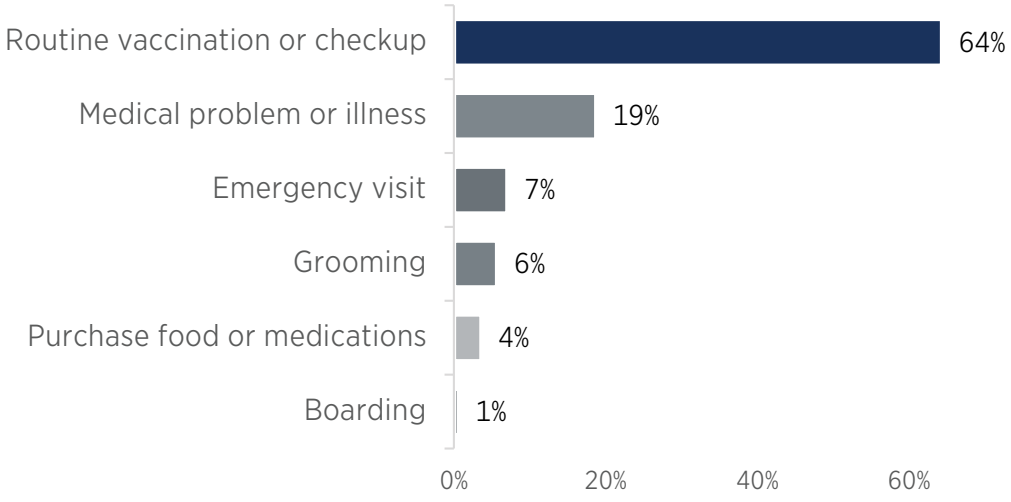
» WHEN WAS THE LAST TIME YOUR CAT SAW A VETERINARIAN?



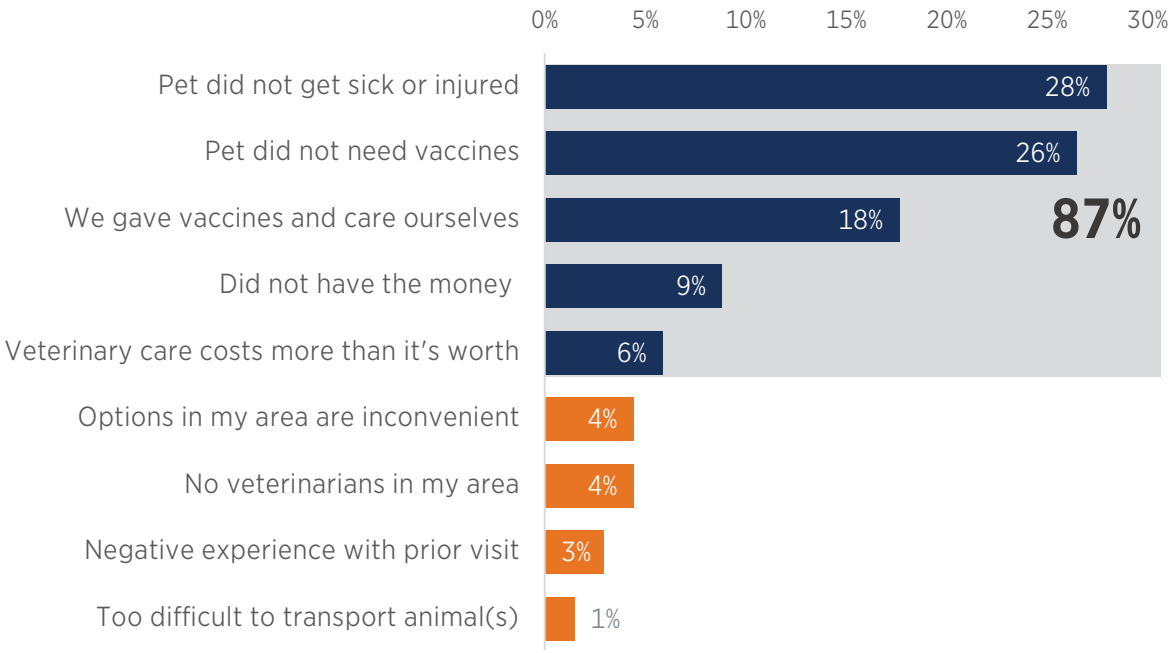
REASONS FOR VISITING THE VETERINARIAN

The most cited reason for visiting the veterinarian was routine vaccinations or checkups at **64%**, followed by medical problems or illness at 19%. Similarly, respondents whose pets had not seen a veterinarian in the last two years were most likely to state that the pet hadn't needed a vaccine, they gave vaccines themselves, or that the pet was not ill or injured. Overall, 87% of respondents cited perceived value and affordability as primary reasons for not seeing a veterinarian. Issues such as convenience and access (location, hours, etc.) accounted for less than 10% of responses.

» REASON FOR LAST VISIT



» REASON FOR NOT SEEING VETERINARIAN



26% of pet owners reported not seeing the veterinarian between **March and December in 2020**.

WAIT TIME IN OFFICE

Dog owners	Cat owners
86% waited 30 minutes or less	**87%** waited 30 minutes or less

How quickly were you able to get an appointment?

27% same day	**29%** same day
39% less than a week	**33%** less than a week
27% within two weeks	**30%** within two weeks
7% three weeks or longer	**8%** three weeks or longer

WAIT TIME

Only **3%** of pet owners had to wait four weeks or longer to book an appointment and **65%** were able to see a veterinarian in less than a week.

KEY TAKEAWAYS

- Pet owners spent a significant portion of their overall pet spending on veterinary care, second only to food.
- Most pet owners saw the veterinarian primarily for vaccinations and routine care.
- Lapsed clients were most likely to cite value-related reasons for not seeing a veterinarian in the last two years (services not needed, cost too high, etc.).
- Convenience (location, hours) and availability of veterinarians did not significantly influence lapsed patient care.
- Communicating the overall value of veterinary care, and providing cost options that align with client budgets are key to ensuring pets see a veterinarian at least once a year.

PET OWNER DEMOGRAPHICS

WHO IS MOST LIKELY TO OWN PETS?

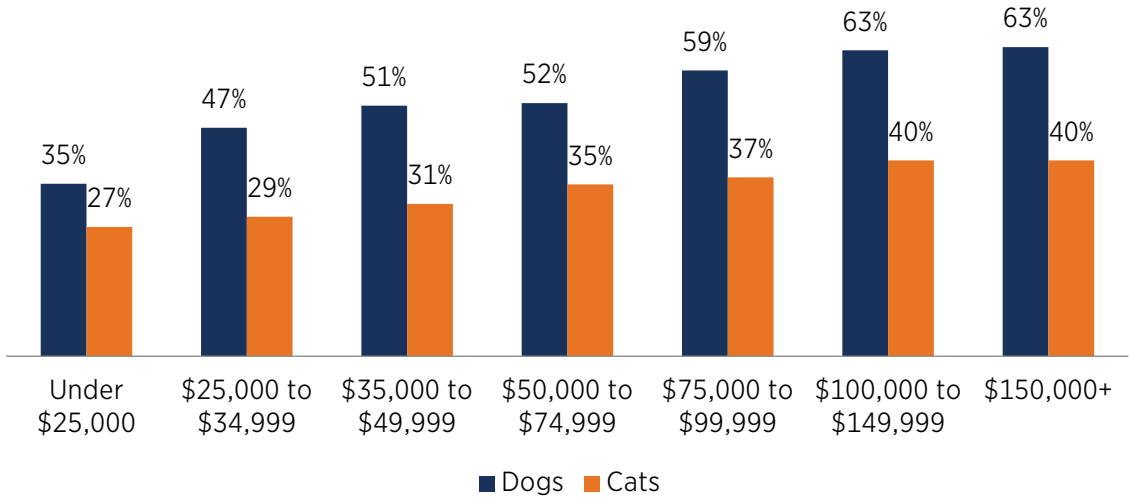
As with previous years, higher income and home ownership were associated with higher rates of pet ownership. However, this relationship was more pronounced in 2020. Comparing 2020 to 2016*, rates of pet ownership were **11%** higher for those making more than $75,000 and were **25%** higher for people living in a house. People who own their own home had pet ownership rates 5% higher than 2016. When compared to an overall increase in pet ownership of less than 1%, we can see a trend of wealthier Americans comprising a higher percentage of pet owners.

**2017-2018 AVMA Pet Ownership and Demographics Sourcebook*

Households with incomes over $100,000 were most likely to own pets:

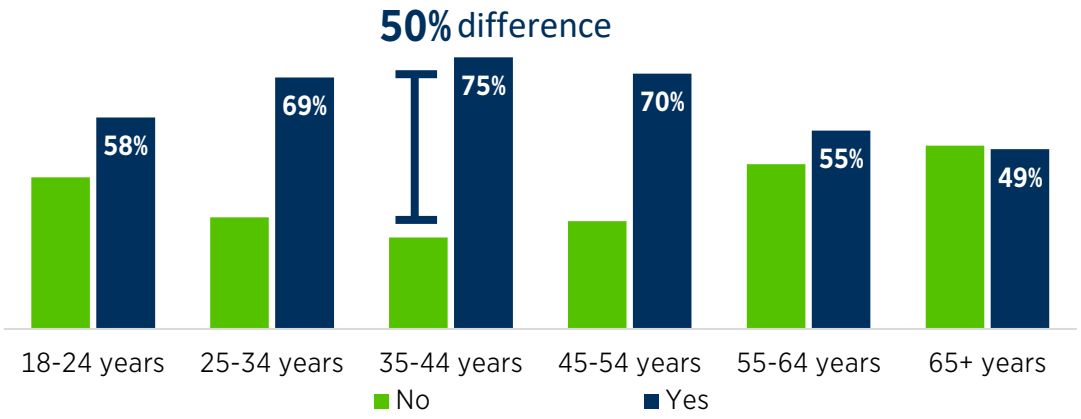
63% own dogs and 40% own cats.

» HOUSHOLD INCOME



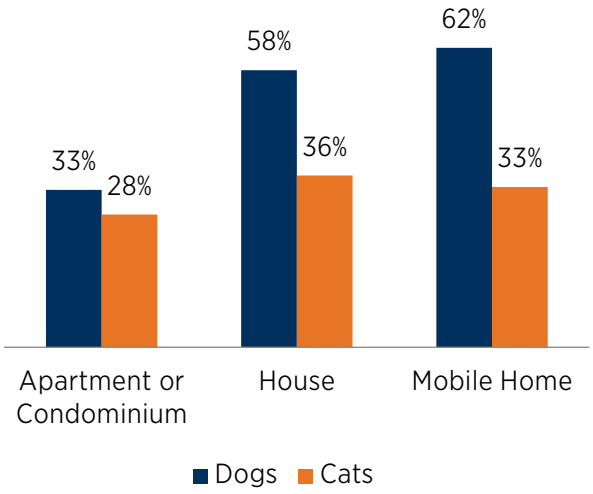
People in the 25–54 age group were most likely to be pet owners.
35-44-year-olds had the highest rate of ownership at 75%.

» PET OWNERSHIP BY AGE

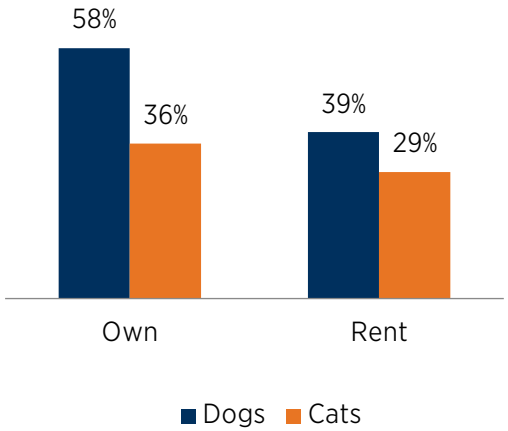


Homeowners—including those in houses and mobile homes—were more likely than apartment dwellers to own dogs, while cat ownership did not vary significantly by home ownership.

» RESIDENCE TYPE



» HOME OWNERSHIP



PET OWNER SEGMENTS

TYPES OF PET OWNERS

Taking a deeper dive into pet ownership, we examined types of pet owners, specifically those who own dogs, and those who own dogs along with other types of animals (cats, birds, etc.). We identified five types of pet owners: low key and child free; pampered pets; casual caretakers; occupied owners; and enthusiastic families. Each of these groups vary in their demographics, behaviors, values, and needs. Understanding each type of pet owner can help practices increase engagement and loyalty among their client base.

PET OWNER SEGMENTS				
Pampered pets My pets are my world, so I value high-quality service.	Less likely to own cats	Single, no kids	Under 35 or 45-54 years old	More likely to make under $25k or over $200k
Enthusiastic families Convenient location and hours are great for my busy family, but overall value is most important to me.	Own dogs and cats	Likely to have children	25-54 years old	Income most likely between $50k–$200k
Low key and child free My pet is a close family member, so I want quality services at the right price point.	Less likely to own cats	No children	Age 55+	Income between $25k-$50k
Occupied owners I may not take my pet to the veterinarian each year, but when I do, I want my pet to receive quality services from knowledgeable staff.	More likely to own dogs	Married or divorced	Under 45 with children under 5 years old, or 65+ without kids	More likely to make under $150k
Casual caretakers My family has several pets to care for so when we go to the veterinarian, we need valuable services at the right price.	Own dogs and cats	Married with kids, own a home	25–44 years old	More likely to make $75k–$200k



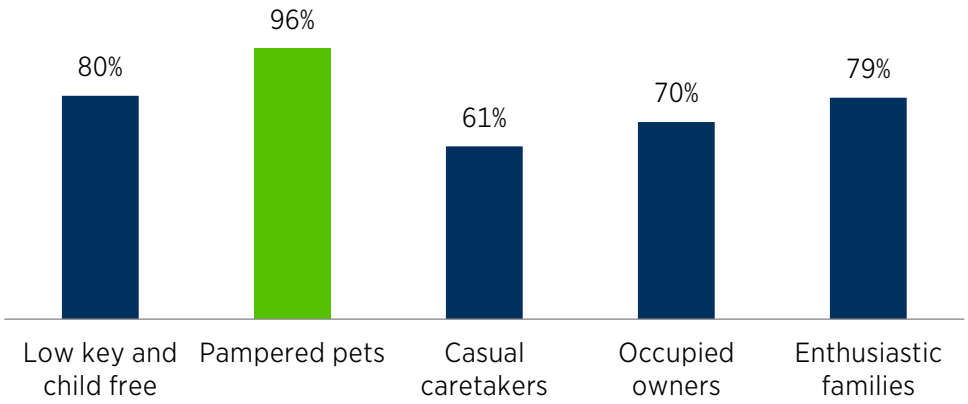




CARING FOR PETS

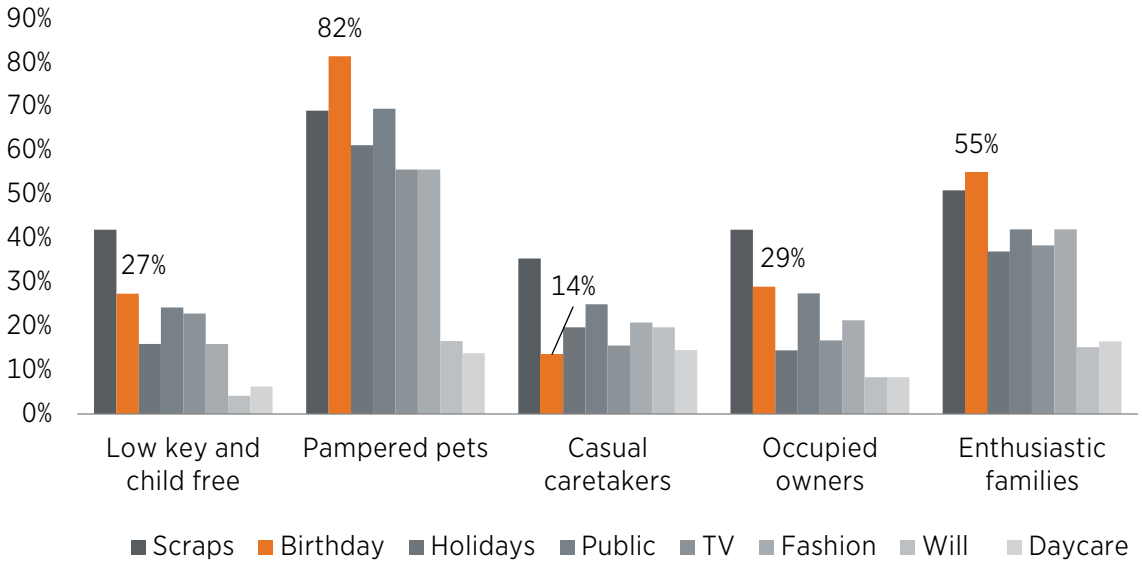
Each segment differs in how they care for pets. Pampered pets and enthusiastic families were the most likely to be highly involved in their pets' lives. This includes celebrating birthdays, holidays, talking to their pet daily, and dressing their pet in fashionable clothing and/or accessories. Casual caretakers have the lowest level of involvement, although 61% of respondents in this group consider their pets a family member.

» DO YOU CONSIDER YOUR PET A FAMILY MEMBER?



In the pampered pets segment, 96% of respondents consider their pet a family member, and 82% celebrate their pet's birthday.

» PET OWNER BEHAVIORS BY SEGMENT



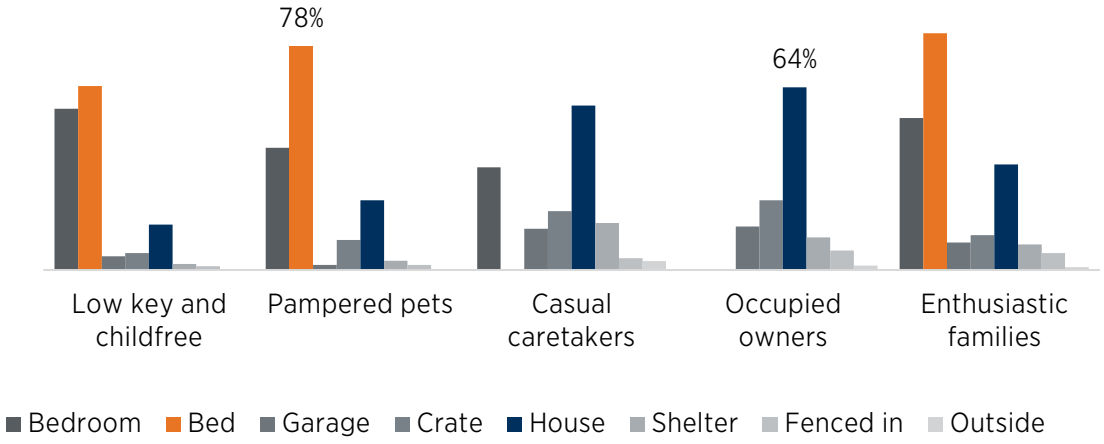
**Holidays refers to celebrating holidays with a pet, public refers to taking a pet out in public places, TV refers to leaving the TV on for a pet while away, and will refers to including a pet in one's will.*

PET OWNER BEHAVIORS VARY BY SEGMENT

Pampered pets	Enthusiastic families	Low key and child free	Casual caretakers	Occupied owners
Celebrate birthdays and holidays, and purchase clothing for pets	Mostly likely to have pets in daycare and use a pet monitor	Less likely to take pictures of pets and dress them up	Still consider their pet's mental health but are less likely to think about it daily	Pets do not sleep in bed or bedroom and are not allowed on furniture
Think about happiness and mental health of pets daily	Pets sleep in the bed or bedroom but are not allowed on furniture	Lower levels of involvement than other segments	Least likely to talk to their pet every day	Most will take pictures of their pet at least once a week

Occupied owners are the least likely to have pets sleep in their bed or bedroom. The majority of respondents in this group (64%) have pets sleep in their house.

» PET SLEEPING ARRANGMENTS BY SEGMENT

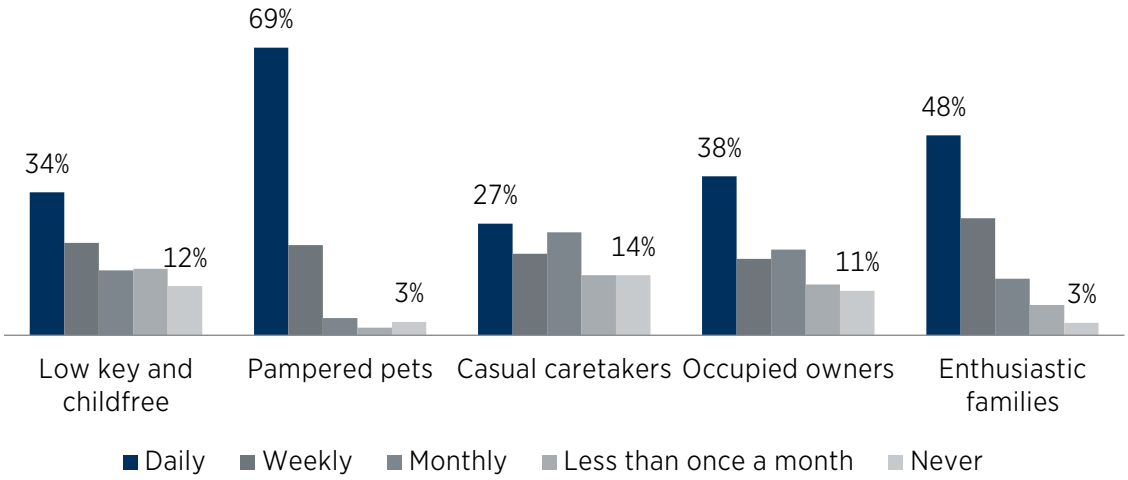




PET'S MENTAL HEALTH

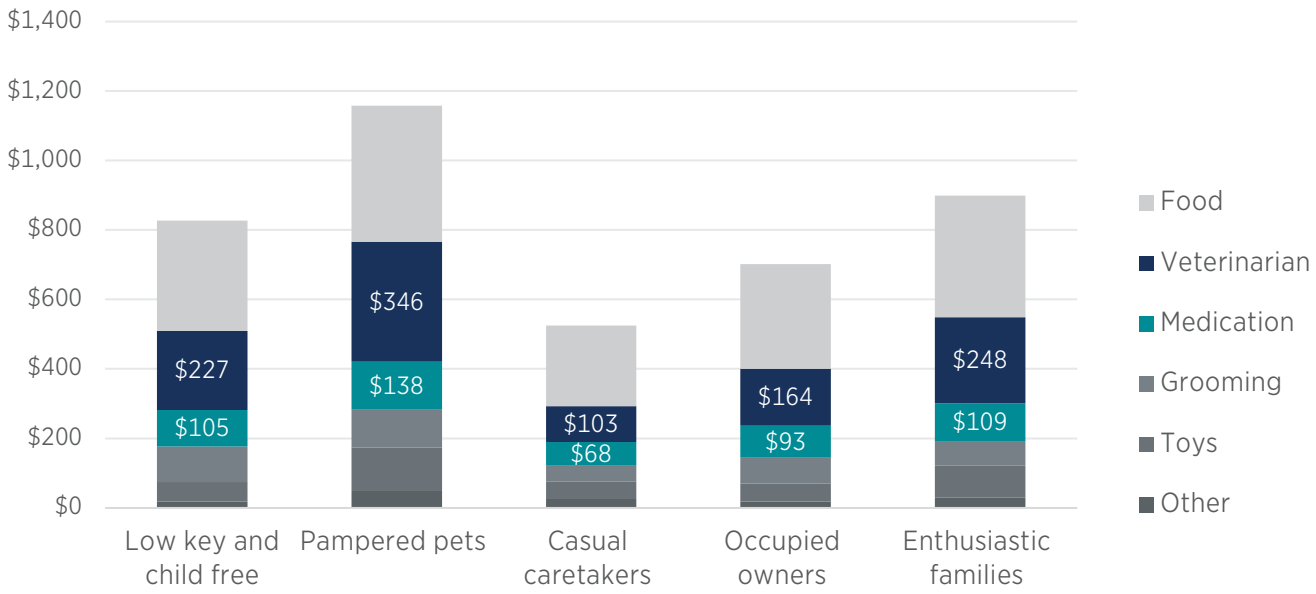
Considering a pet's mental health was another distinction between pet owner segments. Pampered pets and enthusiastic families had the highest rates in this category, with casual caretakers having the lowest rates. It is important to note that the vast majority of casual caretakers (72%) still consider their pet's mental health at least monthly.

» HOW OFTEN DO YOU THINK ABOUT YOUR PET'S MENTAL HEALTH?



Pampered pets spent the most money at the veterinarian, while casual caretakers spent the least.

» ANNUAL SPENDING ON PETS

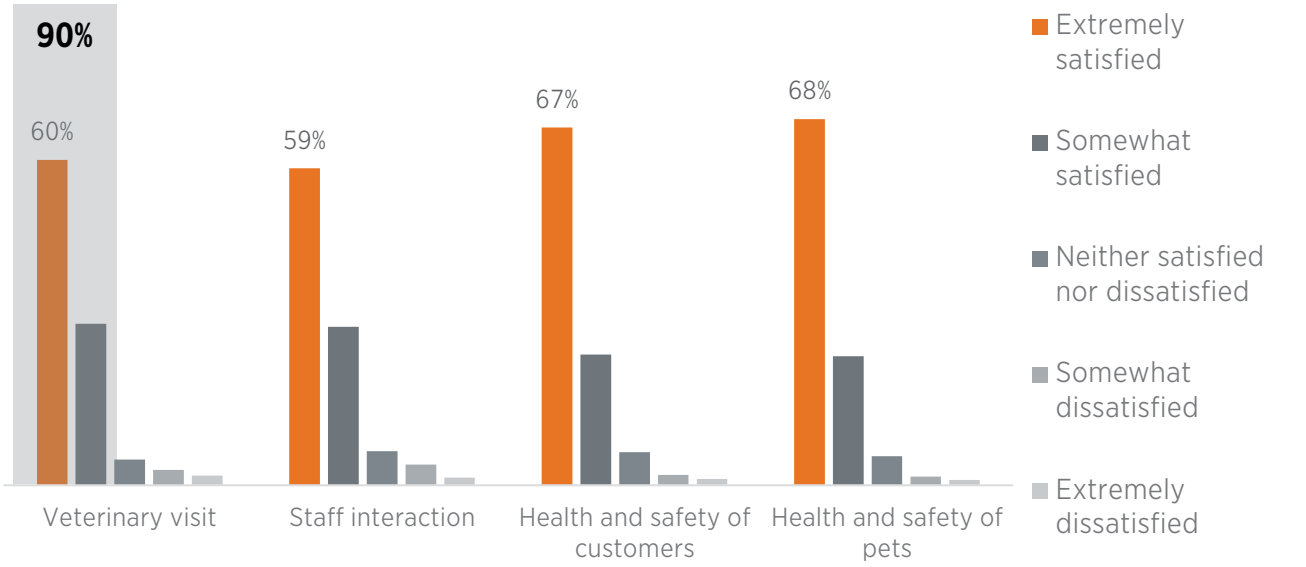


SATISFACTION WITH VETERINARY SERVICES

VETERINARY VISIT SATISFACTION

Most respondents (60%) were extremely satisfied with their veterinary visits and **90% were somewhat to extremely satisfied**. When asked about specific aspects of their last visit, most respondents were extremely satisfied with both concern for health and safety of their pets and themselves, and staff interaction.

» VETERINARY VISIT RATINGS



PRICE VS. VALUE

Key performance indicators

Overall satisfaction

Likelihood of switching veterinary practices

Would you recommend your veterinarian to a friend or family member?

Most influential

Overall value and quality of services

Least influential

Price



WHAT MAKES PEOPLE SWITCH VETERINARY PRACTICES?

Quality services and knowledgeable staff were the most important indicators of whether or not someone would switch practices. Convenience, price, hours, and wait time were not significant predictors of likelihood to switch practices. Focusing on quality services and knowledgeable staff has a higher return on investment (ROI) than price and wait time for many practices.

Price was only significant for households with an income under $75,000. Pet owners in this group were less likely to recommend their veterinarian if they were unsatisfied with the price they were charged.

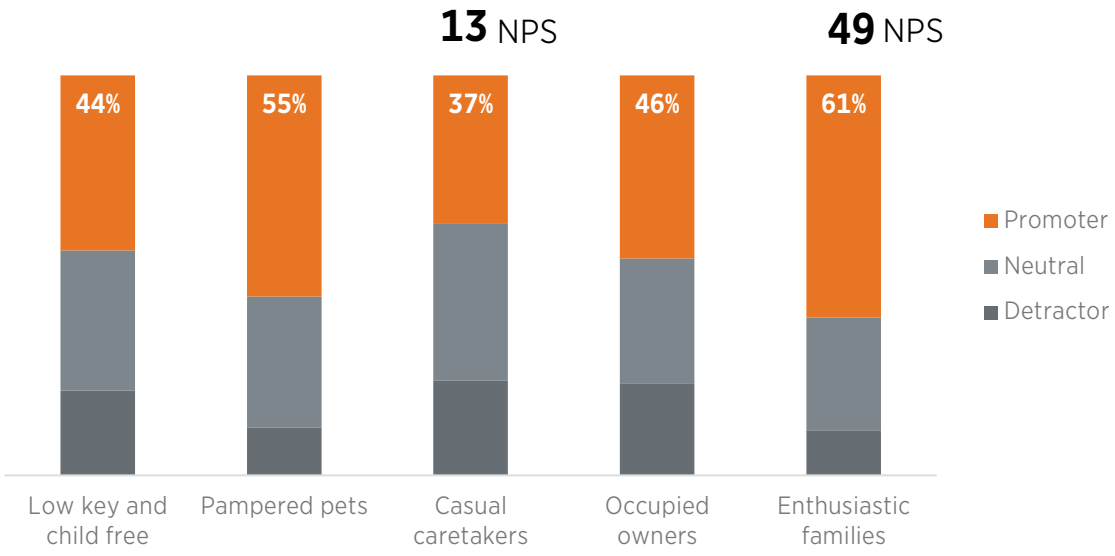
NET PROMOTER SCORE (NPS)

NPS is used as an industry benchmark for companies to understand where their customer experience ranks within a competitive landscape. Business leaders use this metric for insights on brand strength, customer experience management, and growth. Customers are asked how likely they are to recommend a business to a friend or colleague. Respondents are grouped as promoters (9-10), passives (7-8), or detractors (0-6). The NPS can range from -100 to 100 and varies across industries and companies. The score is calculated by subtracting the percentage of detractors from the percentage of promoters. In general, a score above 0 is good, above 20 is favorable, and above 50 is excellent.

For this survey, respondents were asked how likely they are to recommend their veterinarian to a friend or family member. Promoters are more likely to see a veterinarian regularly, spend more on veterinary care, and promote their veterinarian to others. Increasing the percentage of promoters can help strengthen a practice and the entire industry. To do this, we start by understanding the NPS for veterinary practices in general, and what influences the likelihood a client will recommend their veterinarian to others.

The overall NPS for veterinary practices was 34, which is considered a good score and is in line with the human healthcare industry at 38.

» VETERINARY NPS BY PET OWNER SEGMENT



Enthusiastic families had the most promoters (61%) and an NPS of 49.

Casual caretakers had the lowest NPS at 13.

GETTING PROMOTERS AT YOUR PRACTICE

We measured several characteristics to see how they influence a pet owner being categorized as a promoter, neutral, or detractor. **Overall value** and quality of services were most influential on promoter status and convenience was the least influential. In other words, pet owners who rated their veterinary clinic highly on overall value were most likely to be promoters and recommend their clinic to others. Pet owners who rated their clinic low on overall value were most likely to be detractors. Rating a practice low on **convenience** was the least influential on the likelihood to recommend a veterinarian to friends or family members, but for some segments a practice that is highly inconvenient or expensive could be a deal breaker.

WHAT DRIVES PROMOTERS AND DETRACTORS?

Pampered pets I look for the best service money can buy.	Highest level of spending and satisfaction with veterinary services	Least interested in curbside service and telemedicine	Value quality of services and overall value
Enthusiastic families Convenient services are great, but overall value is most important to me.	Prefer practices with as many conveniences as possible (curbside service, contactless payment, online billing, telemedicine, 24-hour service, etc.)		Value quality of services, knowledgeable staff, and overall value
Low key and child free I look for quality service that's within my budget.	Middle of the road spending and satisfaction	Prefer to make appointments over the phone	Value quality of services and price
Casual caretakers If a practice doesn't have knowledgeable staff with cost-effective options, I'll look elsewhere.	Lowest satisfaction with veterinary care and lowest spending on veterinary services	Least likely to see a veterinarian regularly. Value knowledgeable staff and price of services	Prefer practices with 24-hour service and appointment scheduling over the phone
Occupied owners Quality service and knowledgeable staff matter most when finding a practice, but if it's very inconvenient I will switch.	Middle of the road on satisfaction	Value quality of services and knowledgeable staff	

MILLENNIALS AND GEN Z

Long-term profitability is highly dependent on strong loyalty and revenue from Millennials and Gen Z as they overtake baby boomers in the general population and among pet owners. Millennials and Gen Z are more likely to recommend practices with knowledgeable staff, while Gen X and Boomers are more likely to recommend practices with high overall value. Clients of all ages place a high value on friendliness of service.

MILLENNIAL AND GEN Z PREFERENCES

3 times more likely to value telemedicine and curbside services	Twice as likely to value **24-hour** service and contactless payment
2 ½ times more likely to value online billing	Less likely to value scheduling appointments over the phone

Actionable insights

We identified five key pet owner segments: pampered pets; enthusiastic families; low key and child free; occupied owners; and casual caretakers.	Each segment varies on the demographic makeup, behaviors, values, spending, and satisfaction with veterinary care.
Net Promoter Score (NPS) is a key performance indicator that varies by pet owner segment.	Getting to know your clients and their needs is critical for making sure your practice has a high percentage of promoters and a strong NPS.

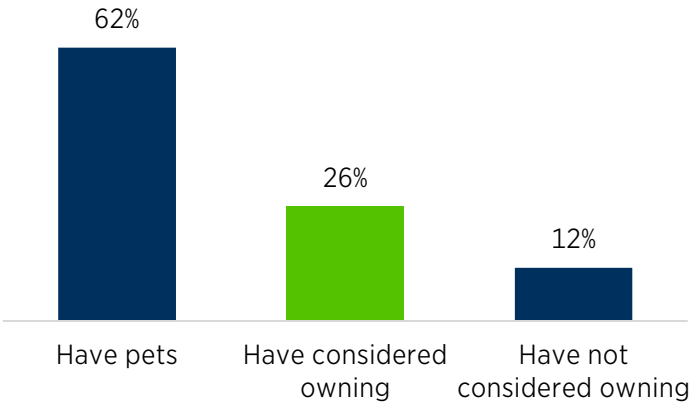
Focusing on value will usually have higher ROI than convenience.



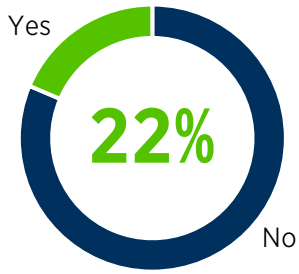
COVID-19 AND ADOPTIONS

Households who acquired pets during COVID-19 were most likely to get a dog (82%), followed by cats (68%). Nearly half of the households who acquired pets during COVID-19 obtained both dogs and cats (47%).

» DO YOU OWN OR HAVE YOU CONSIDERED OWNING A PET?



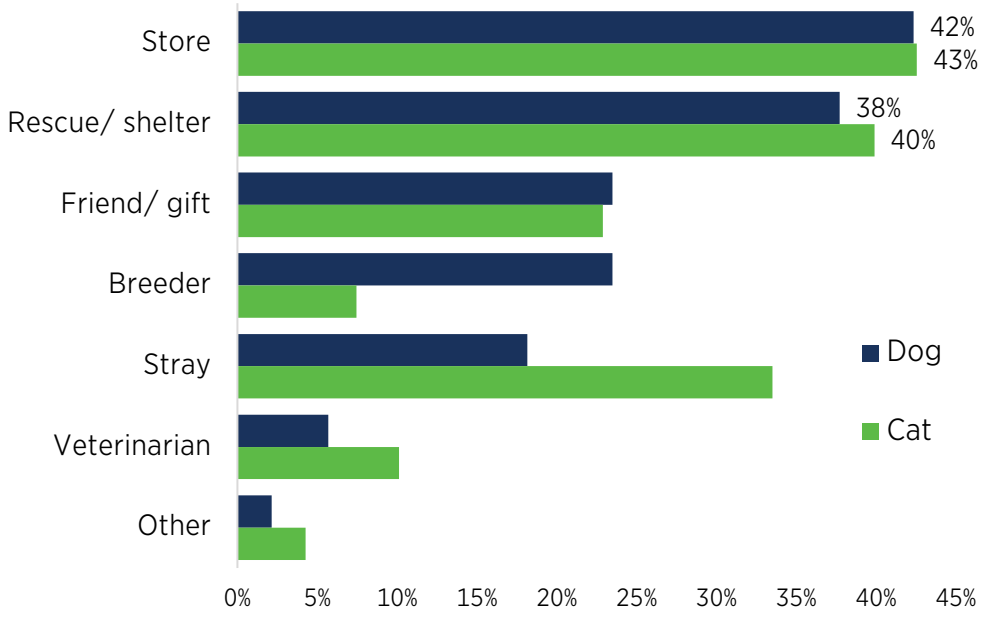
» DID YOU GET A NEW PET SINCE COVID-19 BEGAN?



WHERE ARE PET OWNERS ACQUIRING PETS?

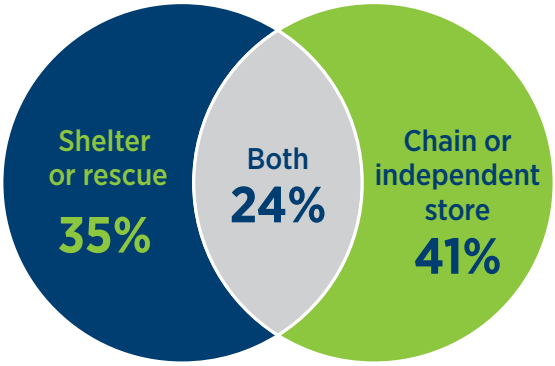
Shelter or rescue adoptions accounted for 38% of dog adoptions and 40% of cat adoptions. Stores accounted for 42% of dog adoptions and 43% of cat adoptions. Rates of acquisition from breeders were more common for dogs (23%) than cats (7%). This is similar to 2016 data that had dog acquisitions from breeders at 22%. Overall, fewer pet owners obtained a pet from a friend, family member, or as a gift. It is important to note that many respondents selected multiple options, meaning they may have obtained their pet(s) from multiple sources. For example, 36% of respondents who obtained a pet from a store also marked a shelter or rescue. This could include pet stores that work with a local shelter or rescue to provide pets with new homes.

» WHERE DID YOU GET YOUR NEW PET?



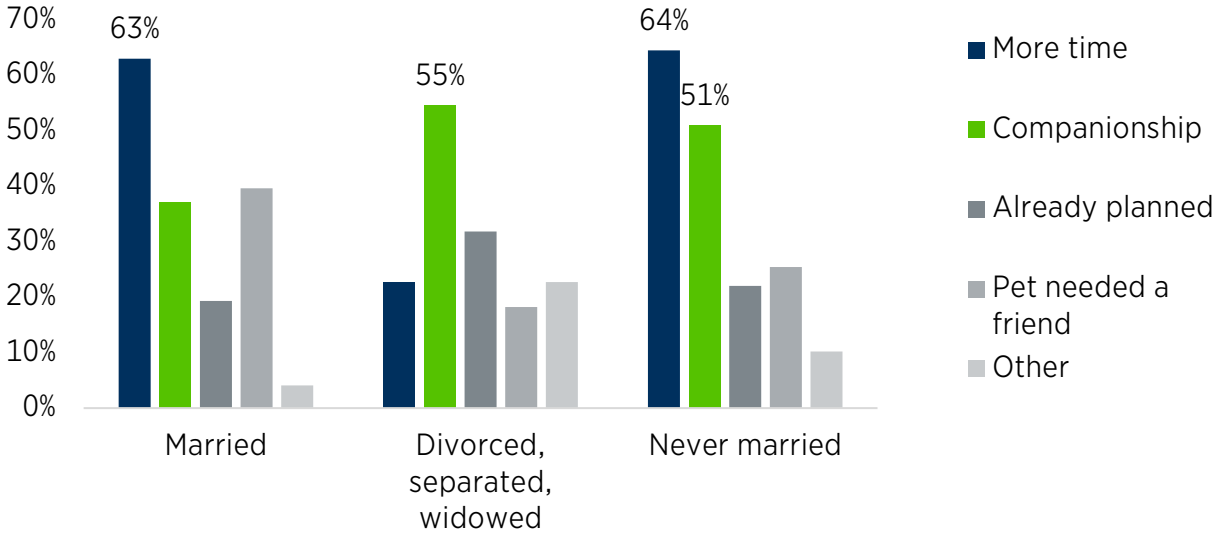
Shelters and rescues were a significant source of pet acquisition in 2020. Many respondents reported using shelters and stores, possibly due to stores working with a local shelter or rescue.

» OF PET OWNERS USING STORES, SHELTERS, OR RESCUES, 24% USED BOTH



Married respondents were most likely to cite having more time as a reason for acquiring a new pet (63%) in 2020. Divorced, separated, and widowed respondents were most likely to cite companionship (55%). Never married respondents cited both having more time (64%) and companionship (51%) as reasons.

» WHY DID YOU GET A NEW PET?



THE ECONOMICS OF PET ADOPTIONS DURING COVID-19

ECONOMICS DRIVE BEHAVIORS, INCLUDING ADOPTIONS

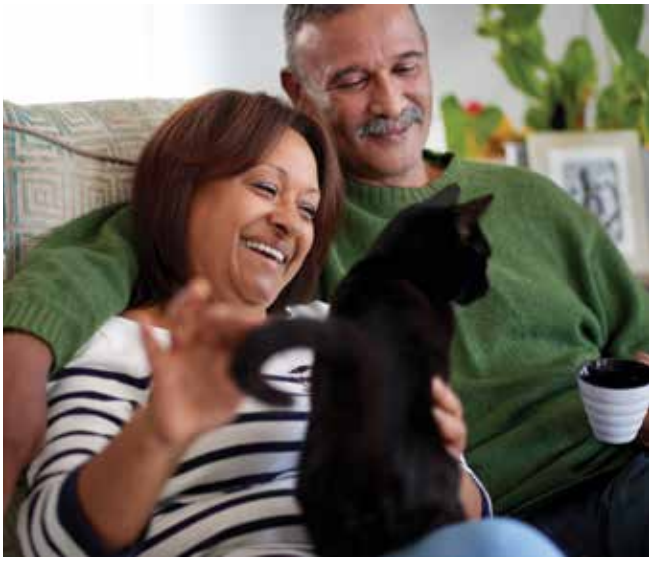
When examining pet ownership and pet owner behaviors, the state of the economy and how it impacts households has a strong influence. During the pandemic, household income, remote work, and changes to financial situations were strong predictors for adopting a pet and visiting a veterinary practice.

WHO WAS MOST LIKELY TO GET A PET?		
Household income **$100k+**	Under **45** years old	Financially the same or better off during **COVID-19**
Working remotely	Married with children	Homeowner

HIGH EARNING REMOTE WORKERS DRIVE ADOPTIONS AND VETERINARY VISITS

There was a distinct trend in who acquired pets during COVID-19. People with more disposable income and the ability to work from home were the most likely to get a new pet. People who worked remotely were **8 times more likely** to get a new pet, and those who worked remotely **and** had a household income of $100k or higher were 9 times more likely to get a new pet. Additionally, 84% of high earning remote workers cited having extra time as the main reason for obtaining a new pet. This was true for both dog and cat owners. A significant number of pet owners did not see a veterinarian during the last nine months of 2020. These owners were more likely to have lower household income and not work remotely. Demand for services is often cyclical, and temporary changes in COVID-19 restrictions may have caused short-term changes in demand. For example, we observed demand for veterinary services spike in late 2020 and early 2021, then flatten during the last half of 2021 (see avma.org/IndustryTracker).

37% of respondents delayed visiting a veterinarian due to COVID-19 and 26% of respondents reported not seeing a veterinarian in 2020 since COVID-19 began.





SEEING THE VETERINARIAN DURING COVID-19

Delayed seeing a veterinarian	Saw a veterinarian during COVID-19
Dog owners **38%**	Dog owners **77%**
Cat owners **42%**	Cat owners **75%**
All pet owners **37%**	All pet owners **74%**
Most likely to delay: Remote workers with children, under 45 years old, under $75k household income	Most likely to see: Households with $75k income or higher, and those who were better off financially during COVID-19

WHAT DOES IT MEAN?

Increases in pet ownership during COVID-19 were driven by economic factors, including increased income and more time spent at home. However, these factors only impacted a small subset of the population (22% of lower income households and 39% of upper income households – see https://www.pewresearch.org/social-trends/2021/03/05/a-year-into-the-pandemic-long-term-financial-impact-weighs-heavily-on-many-americans). Additionally, since this impact was triggered by a pandemic, it isn't likely to be replicated in the near future. Caution is warranted in putting into place permanent solutions for temporary operational changes.



METHODOLOGY

This report is based on a survey conducted by a third-party research panel in early 2021, reflecting 2020 data. There were 5,119 respondents who started the survey (opted in), 723 (or 14.1%) exited on privacy policy, 1,222 (23.9%) were removed for failing validation or having largely inconsistent answers, and 1,163 (22.7%) were removed for duplicates or not finishing the questionnaire. The final respondent count was 2,011 for an actual completion rate of 39.8%.

Several methods can be used to estimate and reduce the nonresponse or coverage bias inherent to opt-in surveys like this one. Such bias can occur when survey respondents are systematically different from nonrespondents in some aspects. One method to minimize this difference is to use statistical adjustments or weightings based on selected demographic, attitudinal, behavioral, or other variables (Dever, Rafferty, Valliant 2008; Mercer et al. 2018). Research has shown that the choice of adjustment technique is not as important as the choice of variables used to make the adjustments (Mercer et al. 2018). We used two separate weighting techniques to ensure the accuracy of pet ownership rates and pet populations. First, we used a range of demographic variables to construct an iterative proportional fitting model. Second, we used a series of behavioral characteristics to weight the data separately. We compared scores and overall opt-in rates with national Gallup polls conducted during the same time period.

Responses to survey questions were also examined for normal distributions. For expenditure metrics, values more than 2 standard deviations above the mean were removed. Data on annual spending pertained to all pets in a single household, whereas data on the cost of last veterinary visit pertained to a specific cat or dog's last visit. It is important to note the previous Pet Ownership and Demographic Survey did not separate medication from veterinary service costs.

Year-over-year comparisons within this study compared 2020 to 2016. The 2016 data came from AVMA's 2017-2018 Pet Ownership and Demographic Survey, which asked respondents about 2016. The current survey was conducted in early 2021 and asked respondents about 2020.

CITATIONS

Dever, Jill A., Ann Rafferty, and Richard Valliant. (2008). Internet Surveys: Can Statistical Adjustments Eliminate Coverage Bias? Survey Research Methods 2(2), 47-60.

Mercer A, Lau A, and Kennedy C. (2018, January). For Weighting Online Opt-In Samples, What Matters Most? Pew Research. https://www.pewresearch.org/methods/2018/01/26/for-weighting-online-opt-in-samples-what-matters-most/



LANGUAGE THAT WORKS

Changing the way we talk about veterinary care



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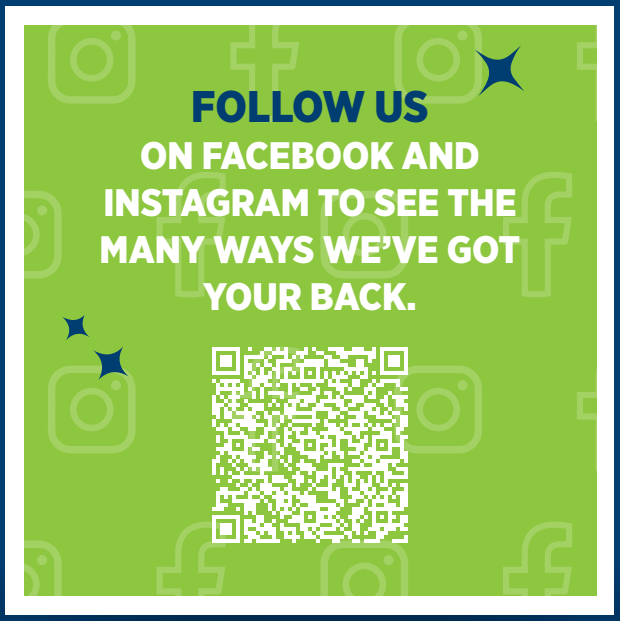
AVMA's Language of Veterinary Care Initiative explores how veterinary teams can harness language to improve patient care.

Find more practical resources and information at **avma.org/LanguageOfCare**.

The Language of Veterinary Care research and tools are made possible in part by educational funding from our partners CareCredit and Pets Best Pet Health Insurance.

AVMA HAS YOUR BACK

We really do! We support you and veterinarians like you by working tirelessly on the important, backbone issues that are crucial to our profession, to quality patient care and to public health—and by identifying future opportunities for veterinarians and the profession.



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2022 AVMA PET OWNERSHIP AND DEMOGRAPHICS SOURCEBOOK