

Data-Driven Insights into Dog Adoption Outcomes and Shelter Length of Stay

Sameh Shamroukh

G. Brint Ryan College of Business, The University of North Texas, Denton, USA

Email: sameh.shamroukh@gmail.com

How to cite this paper: Shamroukh, S. (2026). Data-Driven Insights into Dog Adoption Outcomes and Shelter Length of Stay. *Voice of the Publisher*, 12, 671-688. <https://doi.org/10.4236/vp.2026.124037>

Received: July 25, 2026

Accepted: October 25, 2026

Published: October 28, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Animal shelters face ongoing challenges in managing dog populations while maximizing successful outcomes and minimizing length of stay (LOS). This study analyzes factors associated with adoption versus euthanasia among Sonoma County dog shelter episodes restricted to these two recorded outcomes, using the Sonoma County Animal Shelter Intake and Outcome (ASIO) dataset (County of Sonoma Department of Health Services, 2026), comprising approximately 6000 canine records after filtering. Because return-to-owner, transfer, and other outcomes were excluded, the reported classification probabilities apply only to the adoption-versus-euthanasia comparison. They should not be interpreted as adoption probabilities for all shelter intakes. Key demographic and intake-related variables—including age, size, breed, coat color, sex, intake type, intake subtype, and intake condition—were examined using statistical and machine-learning approaches. Logistic regression and random forest models were applied to classify adoption versus euthanasia. In contrast, a Cox proportional hazards model was used to evaluate time to any recorded shelter exit in the restricted sample. Results indicate that intake condition, age, and size are the most influential predictors of adoption versus euthanasia within the restricted two-outcome sample. Dogs entering shelters in good condition and younger or smaller dogs, particularly puppies, were more often classified as adopted rather than euthanized and generally exited the shelter sooner. Conversely, older dogs, larger dogs, and those with treatable or unknown intake conditions were more often classified as euthanized rather than adopted and were associated with slower shelter exit. Model performance was strong across methods, with both classification approaches achieving 84% - 85% accuracy and ROC AUC values above 0.91. These findings highlight the importance of early identification of dogs at elevated risk of euthanasia or prolonged shelter stays within the restricted analytical population. By leveraging data-driven insights, the Sonoma County shelter system can implement targeted interventions—such as enhanced visibility, foster placement, or behavioral support—

to improve outcomes, reduce overcrowding, and enhance animal welfare. The findings should not be generalized to return-to-owner, transfer, or other excluded outcome pathways.

Keywords

Animal Shelter, Dog Adoption, Length of Stay, Logistic Regression, Random Forest, Cox Proportional Hazards, Animal Welfare

1. Introduction

Across the United States, millions of dogs are admitted to animal shelters each year, which face the difficult challenge of managing large influxes of homeless dogs while aiming to achieve high live release rates (LRR). LRR measures the percentage of animals that leave a shelter alive through positive outcomes such as adoption, return to owner, or transfer to another rescue organization. According to estimates from Shelter Animals Count ([Shelter Animals Count, 2024](#)), approximately 2.9 million dogs entered U.S. shelters in 2024 and 3.2 million in 2023; of these, roughly 2.0 million and 2.2 million were adopted in those respective years. Despite improved adoption rates over time, shelters continue to face challenges, including overcrowding, resource limitations, and prolonged stays ([American Society for the Prevention of Cruelty to Animals \[ASPCA\], 2024](#)).

Not every dog that enters a shelter will be adopted or achieve a live outcome. Factors such as age, breed, and intake condition can influence whether a dog is adopted rather than euthanized, as well as how long the shelter episode lasts. In this study, however, the classification analysis excludes return-to-owner, transfer, and all other outcome categories; consequently, its probabilities describe adoption versus euthanasia only among records with one of those two outcomes.

This study focuses specifically on the dog population within Sonoma County, California, shelter system, using publicly available administrative data. The study centers on two outcomes: 1) a binary classification of adoption versus euthanasia among episodes restricted to those two outcome types and 2) LOS, defined as the number of days from intake to the recorded adoption or euthanasia exit. The classification results, therefore, do not estimate adoption likelihood across all shelter intakes.

The underlying factors associated with these outcomes are often grouped into dog-specific characteristics (age, breed, coat color, size, and sex) and intake-related characteristics (intake type, subtype, and condition). Previous research suggests that age and size play significant roles; however, because outcome patterns depend on local demographics and shelter practices, a focused regional study is necessary to better understand the adoption-versus-euthanasia distinction and LOS within Sonoma County.

Identifying what drives adoption outcomes and LOS has important practical and societal implications. Prolonged shelter stays can negatively affect animal wel-

fare by increasing stress, disease exposure, and behavioral deterioration. Extended stays also contribute to overcrowding and increased costs for food, medical care, and staffing. Shelters that identify which dogs are at greater risk of long stays can reallocate resources accordingly—through specialized fostering, behavioral training, or enhanced digital visibility—thereby improving welfare outcomes for the most vulnerable animals.

The goal of this research is to quantify how demographic and intake characteristics are associated with adoption versus euthanasia and with LOS within the Sonoma County animal shelter system. This study contributes to animal shelter literature in three ways. First, it provides a localized analysis using a large public shelter dataset from Sonoma County, California. Second, it combines logistic regression with random forest classification to identify interpretable and predictive factors associated with adoption rather than euthanasia in a two-outcome sample. Third, it integrates this classification task with an LOS analysis of the time to the next recorded exit, providing operational insights for resource allocation, intervention prioritization, and shelter capacity management.

2. Literature Review

Findings from previous research provide context for understanding why some dogs are adopted quickly while others remain in shelters longer or face euthanasia. Existing studies offer critical insights into how individual dog characteristics and shelter-related factors contribute to adoption success and live-release rates, informing the rationale for a focused analysis of the Sonoma County shelter system.

2.1. Phenotypic Predictors of Adoption

A considerable body of research demonstrates that physical appearance is a primary driver of adoption success. In an analysis of nearly 20,000 shelter records, [Cain et al. \(2020\)](#) found that age is a primary predictor of adoption, with puppies having the highest likelihood of adoption and significantly shorter shelter stays than adult and senior dogs. Dog size also plays a critical role; small dogs generally have shorter LOS and higher live-release rates than large dogs. [Bradley and Rajendran \(2021\)](#) used multiple machine learning algorithms—including gradient boosting, random forest, logistic regression, and artificial neural networks—to confirm that age, size, and coat color are key predictors of duration of care, with gradient boosting performing best overall. Extending on this work, [Cain et al. \(2021\)](#) reported that brachycephalic (short-nosed) dogs were nearly twice as likely to be euthanized, underscoring how morphology can influence outcomes beyond adoption alone.

The role of coat color in adoption outcomes has received considerable attention, though findings are mixed. [Brown et al. \(2013\)](#) found that white, gray, and gold coat colors were associated with a higher likelihood of adoption, partly because they correlated with small body size. In contrast, [Svoboda & Hoffman \(2015\)](#) analyzed 4 years of shelter data from 2 Pacific Northwest shelters and

found that black dogs did not have significantly longer availability than dogs of other colors, challenging the widely reported “black dog syndrome.” Instead, age and breed group—particularly bully breeds—emerged as more consistent and meaningful predictors of LOS and euthanasia risk. Similarly, Nakamura et al. (2020) examined the attributes of photographs in online rescue profiles. They found that photographic features such as ear position and background setting were associated with LOS, independent of coat color. These nuanced findings suggest that color effects may be confounded by breed and size, and that visual presentation factors beyond coat color warrant attention in shelter adoption research.

2.2. Behavioral Factors

While physical traits are influential, behavioral evaluations also play an important role in determining LOS. McGuire et al. (2021) found that dogs evaluated as displaying dangerous behavior during food guarding or dog-to-dog interactions had significantly longer shelter stays. Furthermore, Protopopova et al. (2014) demonstrated that specific in-kennel behaviors—such as leaning on the kennel wall, facing away from the enclosure front, and engaging in back-and-forth motion—were associated with increases in LOS of 15 to 30 additional days, providing shelters with observable, modifiable behavioral targets. Protopopova et al. (2012) also discovered that training dogs to maintain eye contact with potential adopters did not significantly increase adoption rates, suggesting that physical traits may override brief behavioral displays during the selection process.

In contrast, d’Angelo et al. (2022) found that a comprehensive four-month training program significantly increased adoptions of adult and senior dogs in an Italian shelter, but had no impact on already highly adoptable puppies. Corsetti et al. (2021) identified two primary personality dimensions among shelter dogs—“bolder” (self-confident) and “shyer” (insecure)—finding that self-confident dogs displayed greater sociability and playfulness, traits perceived as more desirable by potential adopters. Powell et al. (2025) extended this line of research by examining biological stress markers alongside behavioral observations at three Philadelphia-area shelters, finding that dogs with lower stress indicators were associated with shorter LOS and higher adoption rates. Together, these findings suggest that behavior-based interventions may be most effective for dogs facing adoption disadvantages, and that observable in-kennel behaviors represent actionable targets for shelter staff.

2.3. Shelter Environment, Stress, and Foster Care

The shelter environment has a measurable impact on canine welfare and eventual outcomes, particularly for dogs experiencing extended LOS. Raudies et al. (2021) observed that long-term shelter residents (more than 90 days) exhibited higher stress levels and more frequent stress-related behaviors than short-term residents. Gunter et al. (2021) found that brief outings from the shelter did not reduce phys-

iological stress markers such as cortisol but did significantly improve in-kennel resting behavior. Supporting these findings, [van der Laan et al. \(2023\)](#) demonstrated that dogs rest more effectively in a novel home environment than in a shelter, with a rebound in resting behavior occurring on the second night after adoption.

Foster care programs have emerged as a particularly effective intervention for improving both welfare and adoption outcomes. [Gunter et al. \(2023\)](#) analyzed data from 1955 dogs across 51 shelters and found that brief outings and temporary fostering stays increased dogs' likelihood of adoption by factors of 5.0 and 14.3, respectively, compared with shelter-only controls. [Gunter et al. \(2022\)](#) further documented the role of emergency fostering during the COVID-19 pandemic, finding that foster caregiver engagement was associated with substantially improved dog outcomes, including reduced LOS and higher adoption rates. These findings support the practical recommendation that shelters invest in structured foster networks as a cost-effective strategy for improving outcomes for harder-to-adopt dogs.

2.4. Breed Labeling, Implicit Biases, and Adoption Failure

Implicit human biases further complicate adoption outcomes. [Gunter et al. \(2016\)](#) demonstrated in a multi-study investigation that dogs labeled as "pit bulls" remained in shelters over three times longer than phenotypically similar dogs with different breed labels, and that removing breed labels from kennel cards reduced euthanasia of pit bull-type dogs by 12%. [Quadlin and Montgomery \(2022\)](#) found that dogs with names perceived as racially coded were adopted at different rates, a disparity most pronounced for pit bull-type breeds. [Walker et al. \(2026\)](#) examined outcomes for dogs subject to breed-specific legislation (BSL) in a Midwestern shelter, finding that legislated breeds were significantly more likely to be euthanized and experienced longer LOS than non-legislated breeds.

[Powell et al. \(2021\)](#) identified that adult dogs and pit bull-type dogs are significantly more likely to be returned to the shelter and subsequently euthanized. [Hawes et al. \(2020\)](#) further characterized the predictors of shelter return, finding that age and prior behavioral issues were among the strongest predictors of relinquishment. [Dinwoodie et al. \(2022\)](#) suggested that adopter satisfaction is highest when a dog's home behavior matches the shelter's initial description, underscoring the importance of accurate assessment and communication at the time of adoption. [Ly et al. \(2023\)](#) extended this work by examining community-level vulnerability. They found that socioeconomic factors predicted which types of animals were most likely to be surrendered, pointing to structural inequities in shelter intake patterns that may compound adoption disadvantages for certain dog populations.

2.5. Intake Type, Data Quality, and Shelter Trends

The circumstances under which a dog enters a shelter can influence its subsequent

outcomes. [Rodriguez et al. \(2022\)](#) analyzed national shelter trend data from 2016 to 2020. They found that intake source (stray versus owner surrender) was associated with distinct outcome trajectories: stray intake increased substantially in recent years, while owner surrenders fluctuated. [Ly & Protopopova \(2023\)](#) examined data from a self-rehoming platform and found that animal characteristics influencing owner-initiated rehoming differed from those shaping formal shelter outcomes, suggesting that shelter datasets may undersample certain population segments. [Ly et al. \(2023\)](#) further noted that intake information reported by shelter staff at the point of owner surrender is often inconsistent, as owners sometimes misrepresent their animals' histories or behavioral profiles to improve perceived adoptability.

At a broader systems level, [Shelter Animals Count \(2023\)](#) reported that U.S. shelters have experienced four consecutive years of overcrowding, with non-live outcomes for dogs increasing 24% from 2022 to 2023. These national trends provide important context for localized studies such as the present one and highlight the urgency of identifying which dog characteristics are associated with prolonged stays and euthanasia risk.

2.6. Digital Presentation and Profile Characteristics

Digital presentation has emerged as a modifiable factor that can meaningfully affect the speed of adoption. [Zadeh et al. \(2022\)](#) found that the number of profile photos and sterilization status significantly influenced adoption speed in a large-scale analysis of online pet profiles, suggesting that comprehensive digital profiles reduce LOS. [Nakamura et al. \(2020\)](#) found that photographic attributes—including ear position, background setting, and mouth posture—were significantly associated with LOS among dogs listed on Australia's largest online adoption directory. [Lamb et al. \(2021\)](#) examined the role of photo background type on viewer clicking behavior and perceived sociability, finding that background characteristics influenced online interest in dog profiles. Together, these findings suggest that low-cost changes to how dogs are presented digitally—such as professional photography, varied backgrounds, and complete health information—can improve adoption prospects, particularly for dogs with less favorable phenotypic profiles.

[Wells \(2021\)](#) noted that subtle physical indicators, such as paw preference, may serve as a noninvasive tool for assessing emotional functioning and welfare risk, with ambilateral dogs often exhibiting higher stress and fear reactivity, which may reduce their likelihood of rapid adoption. These behavioral and biological markers complement demographic predictors and may provide additional practical guidance for shelters seeking to identify and support at-risk animals.

2.7. Gaps in the Literature

Despite these insights, several gaps remain. Most studies focus on phenotypic traits across broad geographic regions or specific high-volume shelters. There is limited research specifically quantifying the impact of intake characteristics—such

as whether a dog entered as a stray, an owner surrender, or through confiscation—within a localized system such as the Sonoma County animal shelter. Additionally, few studies integrate both adoption outcome prediction and LOS analysis within a single analytical framework using complementary statistical and machine learning methods. The present study addresses these gaps by examining how demographic and intake characteristics influence adoption outcomes and LOS within this specific regional context, combining logistic regression, random forest classification, and Cox survival analysis to provide both interpretable and predictive insights.

3. Method

3.1. Data Description

Data for this study were sourced from the Sonoma County Open Data Portal, specifically the Animal Shelter Intake and Outcome (ASIO) dataset. This dataset is maintained by the County of Sonoma Department of Health Services and serves as a comprehensive record of animal movement through the Sonoma County Animal Services system. First created in February 2017 and updated regularly, the dataset contained approximately 32,500 rows and 24 columns as of January 26, 2026. The dataset includes all species processed through the shelter system; for this study, records were filtered to include only canine entries.

3.2. Measures

3.2.1. Target Variables

Two target variables were examined. Adoption outcome is a binary variable engineered from the Outcome Type field in the ASIO dataset; a value of 1 (True) indicates adoption and a value of 0 (False) indicates euthanasia. Records with other outcome types (e.g., return to owner, transfer) were excluded. Length of stay (LOS) is a continuous variable representing shelter duration in days, calculated from intake date to outcome date.

3.2.2. Predictor Variables

Animal characteristic variables included breed (up to three breed labels per dog), coat color, sex (mapped to binary male/female after accounting for California's mandatory sterilization requirement for shelter dogs at adoption), size (puppy, toy, small, medium, large, extra-large), and date of birth (used to calculate age at intake in months). Operational variables included intake type (born here, confiscated, owner surrender, stray, adoption return, quarantine, OS appointment, or transfer), intake date, days in shelter, outcome type, and outcome date.

3.3. Data Processing

3.3.1. Data Acquisition

The ASIO dataset is publicly accessible through the Sonoma County Open Data Portal and does not require a subscription. Data were exported in comma-separated value (CSV) format for analysis.

3.3.2. Preprocessing

Column names were standardized to snake_case and variables were cast to appropriate data types: date fields (date of birth, intake date, outcome date) were parsed to datetime format; numeric fields (days in shelter) were converted to numeric types; and categorical fields (type, sex, size, intake type, intake subtype, outcome type, and outcome subtype) were set as categorical variables. Fields not relevant to the research questions (animal ID, kennel number, outcome jurisdiction, outcome ZIP code, location, and count) were removed. The impound number was retained as the episode identifier. The unit of analysis was one shelter episode per impound number, not one unique animal. Multiple episodes associated with the same animal, when present, were retained as separate observations and were not linked longitudinally after animal ID was removed. No duplicate rows were identified. This episode-level treatment may underestimate dependence when the same animal appears in multiple episodes.

3.3.3. Filtering

The dataset was filtered to include only canine shelter episodes ($n = 18,205$ after species filtering). Records were then restricted to episodes ending in Adoption or Euthanasia, yielding a final analytical sample of 6247 episodes (4108 adoptions; 2139 euthanasias). Return-to-owner, transfer, and other outcomes were excluded. Five records in which the recorded date of birth postdated the intake date were treated as data-entry errors; birth dates for these animals were set to missing, while intake date, outcome date, and LOS were retained.

3.3.4. Variable Transformation

Age at intake was calculated in months using the date of birth and intake date; 789 records (13%) were missing birth dates and were excluded from age-related analyses. The breed variable was decomposed into up to three separate breed fields to allow analysis of primary and secondary breed characteristics. Sex and reproductive status were combined into a binary variable (male/female), given California's requirement that all shelter dogs be sterilized prior to adoption.

3.4. Data Analysis

3.4.1. Missing Data

Missing values were limited: name was missing for 998 records (16%), size for 3 records, date of birth for 789 records (13%), and outcome subtype and outcome condition for 2 records each. Prior to model fitting, missing numeric values were imputed with the median, and missing categorical values with the mode.

3.4.2. Modeling Strategy

Two complementary modeling approaches were used for the binary classification of adoption versus euthanasia within the restricted two-outcome sample. Logistic regression was selected for its interpretability and to generate coefficients and odds ratios that describe the direction and magnitude of predictive associations. A random forest classifier was used to capture nonlinear relationships and inter-

actions. For LOS, a Cox proportional hazards model was fitted with the event defined as any recorded shelter exit in the analytical sample, whether adoption or euthanasia. Thus, the Cox model estimates the rate of exit from the shelter and not the cause-specific rate of adoption. Euthanasia was not treated as censoring because it precludes later adoption; a cause-specific adoption model would require explicit competing-risks methods.

The final logistic regression and random forest models used the following predictors: age at intake (months), sex, size, primary breed, coat color, intake type, intake subtype, and intake condition. The Cox LOS model used the same set of predictors. Breeds with fewer than 50 episodes were grouped into an “Other” category to reduce sparsity. Records with an intake condition of “untreatable” were removed from the adoption-versus-euthanasia classification models because this condition effectively determined the outcome. The dataset was split 80/20 into training and test sets, stratified by the binary outcome. Categorical variables were one-hot encoded, with one reference category omitted per variable.

4. Results

4.1. Descriptive Statistics

The analytical sample comprised 6247 canine shelter episodes: 4108 (65.8%) ended in adoption, and 2139 (34.2%) ended in euthanasia. These proportions apply only to the restricted two-outcome sample and are not shelter-wide adoption or euthanasia rates. **Table 1** presents summary statistics for LOS and age variables.

Table 1. Summary statistics for length of stay and age at intake.

Variable	n	Mean	SD	Min	Q1	Median	Q3	Max
Length of stay (days)	6247	38.96	55.33	0	14	24	43	865
Age at intake (months)	5458	32.53	35.68	0	9	21	43	228
Age at outcome (months)	5458	33.87	35.81	0	10	23.5	44	229

LOS was right-skewed with a long tail. The median LOS was 24 days, and the interquartile range was 14 to 43 days; however, the mean (38.96 days) was elevated due to a subset of long-stay cases. LOS ranged from 0 to 865 days. **Table 2** presents LOS by outcome type.

Table 2. Length of stay by outcome type.

Outcome	n	Mean	SD	Min	Q1	Median	Q3	Max
Adoption	4108	45.40	62.23	0	15	28	51	865
Euthanasia	2139	26.58	35.63	0	11	18	31	530

The adoption group showed a longer tail (maximum of 865 days) than the euthanasia group (maximum of 530 days), with 9 adopted dogs exceeding the longest recorded stay for euthanized dogs. This finding is notable given assumptions

that prolonged stays predict euthanasia. Adoption rates varied markedly by size: puppies were adopted at rates exceeding 91%, and toy and small dogs at rates above 78%, while adoption rates for medium and large dogs ranged from 47% to 62%.

4.2. Logistic Regression Model

The logistic regression model achieved an accuracy of 83.5% and an ROC AUC of 0.92 on the test set: **Table 3** and **Table 4** present model performance and the confusion matrix.

Within the adoption-versus-euthanasia classification task, the strongest positive coefficient was for puppy size (OR = 10.69), followed by Golden Retriever as the primary breed (OR = 6.05) and toy size (OR = 3.01). Several other primary-breed categories (Great Pyrenees, Great Dane, Akita, Parson Russell Terrier, and Boston Terrier) and coat colors (gray and white/cream) also received positive coefficients. **Table 5** presents the 10 largest odds ratios.

Table 3. Logistic regression model performance.

Outcome	Precision	Recall	F1-Score	Support
Euthanasia	0.62	0.85	0.72	268
Adoption	0.94	0.83	0.88	822
Overall accuracy			0.84	1090
ROC AUC			0.92	1090

Table 4. Logistic regression confusion matrix.

	Predicted: Euthanasia	Predicted: Adoption
Actual: Euthanasia	227	41
Actual: Adoption	139	683

Table 5. Top 10 odds ratios from logistic regression model.

Feature	Coefficient	Odds Ratio
size_PUPPY	2.369	10.69
breed1_GOLDEN RETRIEVER	1.800	6.05
breed1_GREAT PYRENEES	1.149	3.15
breed1_GREAT DANE	1.113	3.04
size_TOY	1.101	3.01
breed1_AKITA	1.095	3.00
breed1_PARSON RUSSELL TERRIER	0.995	2.70
size_SMALL	0.993	2.70
color_GRAY	0.992	2.70
color_WHITE/CREAM	0.909	2.48

Because **Table 5** reports coefficients and odds ratios without confidence intervals or p-values, these logistic regression estimates are interpreted as predictive model quantities rather than as inferential evidence of statistically significant associations. Overall, size (especially puppy), intake condition, age, selected primary-breed categories, and coat color contributed meaningfully to classification performance, but statistical reliability cannot be claimed without uncertainty estimates.

4.3. Random Forest Classifier

The random forest model achieved an accuracy of 84.9% and a ROC AUC of 0.93, marginally outperforming logistic regression on the held-out test set for classifying adoption versus euthanasia. **Table 6** and **Table 7** present model performance and the confusion matrix. These metrics apply only to episodes with adoption or euthanasia outcomes.

Table 6. Random forest model performance.

Outcome	Precision	Recall	F1-Score	Support
Euthanasia	0.65	0.85	0.73	268
Adoption	0.95	0.85	0.89	822
Overall accuracy			0.85	1090
ROC AUC			0.93	1090

Table 7. Random forest confusion matrix.

	Predicted: Euthanasia	Predicted: Adoption
Actual: Euthanasia	228	40
Actual: Adoption	125	697

Feature importance scores (**Table 8**) indicated that intake-condition variables were the strongest overall predictors, with the healthy intake condition (importance = 0.273) and the unknown intake condition (importance = 0.217) ranking first and second, respectively. Age at intake ranked third (importance = 0.141), followed by treatable/manageable intake condition, pit bull breed, and size categories.

Table 8. Top 10 random forest feature importances.

Feature	Importance
Intake condition: healthy	0.273
Intake condition: unknown	0.217
Age at intake (months)	0.141
Intake condition: treatable/manageable	0.050

Continued

Breed: Pit Bull	0.036
Size: puppy	0.033
Size: large	0.029
Size: medium	0.022
Size: small	0.019
Intake condition: treatable/rehab	0.018

Bivariate correlations with adoption outcome (**Table 9**) further confirmed these patterns: healthy intake condition had the strongest positive correlation ($r = 0.518$), and unknown intake condition the strongest negative correlation ($r = -0.504$), with pit bull breed, treatable/manageable condition, large size, and older age also negatively correlated with adoption.

Table 9. Top 10 absolute bivariate correlations with adoption outcome.

Feature	Correlation with Adoption
Intake condition: healthy	0.518
Intake condition: unknown	-0.504
Breed: Pit Bull	-0.205
Intake condition: treatable/manageable	-0.204
Size: large	-0.177
Age at intake (months)	-0.177
Size: puppy	0.176
Intake subtype: field stray	-0.173
Intake type: quarantine	-0.165
Size: medium	-0.163

4.4. Length of Stay: Cox Proportional Hazards Model

A Cox proportional hazards model was used to examine predictors of shelter LOS, with the event defined as any recorded exit in the restricted analytical sample (adoption or euthanasia). A hazard ratio (HR) greater than 1 indicates a faster exit from the shelter (shorter LOS), whereas an HR below 1 indicates a slower exit (longer LOS). The model does not estimate time to adoption because euthanasia prevents later adoption and was not modeled as censoring. Predictor variables were identical to those used in the classification models. **Table 10** presents the finalized Cox model results.

Model assumption checks are summarized in **Table 11**. The proportional hazards assumption was evaluated using Schoenfeld residual tests; influential observations were assessed using deviance residuals; multicollinearity was assessed using variance inflation factors (VIF); and functional form was evaluated using

Table 10. Cox proportional hazards model results for length of stay.

Predictor	Hazard Ratio	95% CI	<i>p</i> -value	Interpretation
size_PUPPY	2.45	2.18 - 2.75	<0.001	Faster shelter exit
size_TOY	1.82	1.61 - 2.05	<0.001	Faster shelter exit
size_SMALL	1.54	1.39 - 1.71	<0.001	Faster shelter exit
size_LARGE	1.00	Reference	Reference	Reference category
age_at_intake_months	0.992	0.989 - 0.995	<0.001	Older dogs stay longer.
intake_condition_HEALTHY	1.73	1.56 - 1.92	<0.001	Faster shelter exit
intake_condition_UNKNOWN	0.68	0.61 - 0.76	<0.001	Slower shelter exit
intake_condition_TREATABLE/MANAGEABLE	0.79	0.71 - 0.88	<0.001	Slower shelter exit
breed_PIT BULL	0.84	0.76 - 0.93	0.001	Slower shelter exit

Table 11. Cox proportional hazards model assumption checks.

Assumption	Test/Diagnostic	Result	Interpretation
Proportional hazards	Schoenfeld residual test	$p = 0.17$	Assumption met
Influential observations	Deviance residuals	No substantial outliers detected	No major influential cases
Multicollinearity	VIF or correlation review	All VIF values < 2.5	Acceptable multicollinearity
Functional form	Martingale residuals	No systematic pattern observed	Continuous predictors are adequately specified

Martingale residuals for continuous predictors.

The finalized Cox estimates indicate that puppies, toy dogs, small dogs, and dogs recorded as healthy at intake exited the shelter faster than their reference categories. In contrast, older dogs, pit bull-type dogs, and dogs with unknown or treatable/manageable intake conditions exited more slowly. These hazard ratios describe time to any recorded exit, not time to adoption, and therefore should not be interpreted as adoption hazards.

5. Discussion

The primary objective of this study was to quantify how demographic and intake characteristics relate to adoption versus euthanasia and LOS in the Sonoma County animal shelter system. Two research questions guided the analysis: (a) Which dog and intake characteristics are most useful for classifying adoption versus euthanasia among episodes restricted to these two outcomes? (b) How do these characteristics relate to the rate of any recorded shelter exit?

5.1. Summary of Findings

Both logistic regression and random forest models achieved similar predictive accuracy (84% - 85%) for distinguishing adoption from euthanasia in the restricted sample and identified consistent patterns. Intake condition emerged as the strong-

est predictor, with healthy dogs more often classified as adopted than as euthanized, compared with dogs presenting with unknown or treatable conditions. Age and size were also important: more than 91% of puppies in the restricted sample were adopted, and toy and small dogs had odds ratios approximately 2.5 to 3.0 relative to large dogs. Breed-specific differences were also observed: Golden Retrievers received positive adoption coefficients, whereas pit bull-type dogs showed a negative association with adoption and a higher frequency of euthanasia within the two-outcome sample.

These findings are broadly consistent with prior research demonstrating that younger and smaller dogs are more often adopted and often experience shorter shelter stays (Cain et al., 2020; Bradley & Rajendran, 2021). The strong predictive contribution of puppy status supports earlier findings that age is among the most important variables in shelter outcome models. The importance of intake condition extends the existing literature by showing that health-related information collected at intake can serve as an early operational signal in the adoption-versus-euthanasia classification task.

The negative predictive association for pit bull-type dogs aligns with prior studies documenting outcome disadvantages for this breed group (Powell et al., 2021; Quadlin & Montgomery, 2022). These findings suggest that targeted adoption campaigns, enhanced digital profiles, foster placement, and behavioral support programs may be particularly beneficial for dogs that the model classifies as being at elevated risk of euthanasia or prolonged shelter stay. Because other outcome pathways were excluded, the results do not establish these dogs' adoption probabilities across all shelter intakes.

LOS analysis indicated that some dogs remained in the shelter for nearly three years before adoption, while the longest recorded stay for a euthanized dog was approximately 1.5 years. Prolonged stay was therefore not deterministically associated with euthanasia. The Cox model complements these descriptive results by estimating relative rates of any recorded exit; it does not isolate time to adoption. A future competing-risks analysis should estimate cause-specific or subdistribution hazards for adoption while treating euthanasia as a competing event.

5.2. Limitations

Several limitations should be acknowledged. First, the dataset lacks behavioral assessment variables (e.g., temperament, reactivity, biddability) that research suggests are important predictors of adoption outcomes (McGuire et al., 2021). Although some shelters collect behavioral data after initial assessment periods, these were not available in the ASIO dataset. Future studies should incorporate behavioral variables where available.

Second, the study relies on administrative records that may contain missing values, inconsistent category labels, or data entry errors. For example, 13% of records were missing the date of birth, limiting age calculation. Breed labels in shelter datasets are typically based on visual assessment rather than genetic testing, which

introduces measurement error into breed-specific findings.

Third, the analysis is limited to one county shelter system and to episodes ending in adoption or euthanasia. Return-to-owner, transfer, and other outcomes were excluded, so the reported probabilities and performance metrics cannot be generalized to all shelter intakes or interpreted as shelter-wide adoption likelihood. In addition, the unit of analysis was the impound episode. Multiple episodes from the same animal may have been retained as independent observations, thereby creating within-animal dependence. Future studies should preserve animal identifiers and use linked or clustered methods where repeated episodes occur.

5.3. Future Directions

Future research should examine adoption return as a distinct outcome. Although this study defines adoption as successful shelter exit, a subset of adopted dogs are subsequently returned (intake type = adoption return). Studying the characteristics associated with failed adoptions and the impact of adoption return status on subsequent adoption likelihood and LOS would allow shelters to improve adoption-matching processes and provide targeted support for re-entered dogs through behavioral or foster programs.

Future studies should also incorporate behavioral assessment data, online profile characteristics (e.g., photo quality, number of images, and profile views), and post-adoption outcomes. For LOS, future work should use a competing-risks framework that models adoption and euthanasia as mutually exclusive exit events. These additions may improve predictive accuracy and provide more precise operational guidance for shelter marketing, intake practices, and intervention design.

6. Conclusion

The findings of this study have practical implications for daily operations and resource allocation within the Sonoma County animal shelter system. By identifying intake condition, age, and size as important predictors of adoption versus euthanasia and of time to any recorded exit, this research provides a framework for flagging vulnerable shelter episodes at intake. This early identification can support resource allocation, including professional photography, social media outreach, foster placement, and behavioral support for dogs with elevated modeled risk. The classification probabilities apply only to records ending in adoption or euthanasia and should not be generalized to other outcomes, such as return-to-owner, transfer, or other outcomes. Used within these limits, the models may help reduce prolonged stays, chronic stress exposure, overcrowding, and resource constraints.

Ethics Statement

This study was conducted in accordance with all applicable ethical standards for research involving animals. Prior to data collection, the research protocol was reviewed and approved by the appropriate institutional ethics committee, and all

procedures complied with relevant institutional, national, and international guidelines for the ethical treatment and welfare of animals. To preserve the integrity of the double-anonymous peer review process, identifying details of the approving institution and ethics approval number have been omitted from this version of the manuscript. These details will be provided in the final accepted version of the manuscript.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

- American Society for the Prevention of Cruelty to Animals (2024). *U.S. Animal Shelter Statistics*.
<https://www.asPCA.org/helping-shelters-people-pets/us-animal-shelter-statistics>
- Bradley, J., & Rajendran, S. (2021). Increasing Adoption Rates at Animal Shelters: A Two-Phase Approach to Predict Length of Stay and Optimal Shelter Allocation. *BMC Veterinary Research*, 17, Article No. 70. <https://doi.org/10.1186/s12917-020-02728-2>
- Brown, W. P., Davidson, J. P., & Zuefle, M. E. (2013). Effects of Phenotypic Characteristics on the Length of Stay of Dogs at Two No Kill Animal Shelters. *Journal of Applied Animal Welfare Science*, 16, 2-18. <https://doi.org/10.1080/10888705.2013.740967>
- Cain, C. J., Woodruff, K. A., & Smith, D. R. (2020). Phenotypic Characteristics Associated with Shelter Dog Adoption in the United States. *Animals*, 10, Article 1959. <https://doi.org/10.3390/ani10111959>
- Cain, C. J., Woodruff, K. A., & Smith, D. R. (2021). Factors Associated with Shelter Dog Euthanasia versus Live Release by Adoption or Transfer in the United States. *Animals*, 11, Article 927. <https://doi.org/10.3390/ani11040927>
- Corsetti, S., Pimpolari, L., & Natoli, E. (2021). How Different Personalities Affect the Reaction to Adoption of Dogs Adopted from a Shelter. *Animals*, 11, Article 1816. <https://doi.org/10.3390/ani11061816>
- County of Sonoma Department of Health Services (2026). *Animal Shelter Intake and Outcome*. County of Sonoma Open Data Portal.
<https://data.sonomacounty.ca.gov/Government/Animal-Shelter-Intake-and-Outcome/924a-vesw>
- d'Angelo, D., Sacchettino, L., Quaranta, A., Visone, M., Avallone, L., Gatta, C. et al. (2022). The Potential Impact of a Dog Training Program on the Animal Adoptions in an Italian Shelter. *Animals*, 12, Article 1759. <https://doi.org/10.3390/ani12141759>
- Dinwoodie, I. R., Zottola, V., Kubitz, K., & Dodman, N. H. (2022). Selection Factors Influencing Eventual Owner Satisfaction about Pet Dog Adoption. *Animals*, 12, Article 2264. <https://doi.org/10.3390/ani12172264>
- Gunter, L. M., Barber, R. T., & Wynne, C. D. L. (2016). What's in a Name? Effect of Breed Perceptions & Labeling on Attractiveness, Adoptions & Length of Stay for Pit-Bull-Type Dogs. *PLOS ONE*, 11, e0146857. <https://doi.org/10.1371/journal.pone.0146857>
- Gunter, L. M., Blade, E. M., Gilchrist, R. J., Nixon, B. J., Reed, J. L., Platzer, J. M. et al. (2023). The Influence of Brief Outing and Temporary Fostering Programs on Shelter Dog Welfare. *Animals*, 13, Article 3528. <https://doi.org/10.3390/ani13223528>
- Gunter, L. M., Gilchrist, R. J., Blade, E. M., Barber, R. T., Feuerbacher, E. N., Platzer, J. M. et al. (2021). Investigating the Impact of Brief Outings on the Welfare of Dogs Living in

- US Shelters. *Animals*, 11, Article 548. <https://doi.org/10.3390/ani11020548>
- Gunter, L. M., Gilchrist, R. J., Blade, E. M., Reed, J. L., Isernia, L. T., Barber, R. T. et al. (2022). Emergency Fostering of Dogs from Animal Shelters during the COVID-19 Pandemic: Shelter Practices, Foster Caregiver Engagement, and Dog Outcomes. *Frontiers in Veterinary Science*, 9, Article 862590. <https://doi.org/10.3389/fvets.2022.862590>
- Hawes, S. M., Kerrigan, J. M., Hupe, T., & Morris, K. N. (2020). Factors Informing the Return of Adopted Dogs and Cats to an Animal Shelter. *Animals*, 10, Article 1573. <https://doi.org/10.3390/ani10091573>
- Lamb, F., Andrukonis, A., & Protopopova, A. (2021). The Role of Artificial Photo Backgrounds of Shelter Dogs on Pet Profile Clicking and the Perception of Sociability. *PLOS ONE*, 16, e0255551. <https://doi.org/10.1371/journal.pone.0255551>
- Ly, L. H., & Protopopova, A. (2023). Predictors of Successful Diversion of Cats and Dogs Away from Animal Shelter Intake: Analysis of Data from a Self-Rehoming Website. *Animal Welfare*, 32, e13. <https://doi.org/10.1017/awf.2023.8>
- Ly, L. H., Chadder, M., Bacon, H., & Protopopova, A. (2023). A Mixed-Method Analysis of the Consistency of Intake Information Reported by Shelter Staff Upon Owner Surrender of Dogs. *Journal of Applied Animal Welfare Science*, 28, 259-280. <https://doi.org/10.1080/10888705.2023.2250254>
- McGuire, B., Chan, J., Jean-Baptiste, K., Kok, P., & Rosenbaum, E. (2021). Results of Behavioral Evaluations Predict Length of Stay for Shelter Dogs. *Animals*, 11, Article 3272. <https://doi.org/10.3390/ani1113272>
- Nakamura, M., Dhand, N., Wilson, B., Starling, M., & McGreevy, P. (2020). Picture Perfect Pups: How Do Attributes of Photographs of Dogs in Online Rescue Profiles Affect Adoption Speed? *Animals*, 10, Article 152. <https://doi.org/10.3390/ani10010152>
- Powell, L., Graham, K., Grant, L., Lenz, O., Reinhard, C. L., Yost, H. et al. (2025). Insights into Shelter Dog Outcomes Using Behavioral and Biological Stress Markers. *Physiology & Behavior*, 300, Article ID: 115040. <https://doi.org/10.1016/j.physbeh.2025.115040>
- Powell, L., Reinhard, C., Satriale, D., Morris, M., Serpell, J., & Watson, B. (2021). Characterizing Unsuccessful Animal Adoptions: Age and Breed Predict the Likelihood of Return, Reasons for Return and Post-Return Outcomes. *Scientific Reports*, 11, Article No. 8018. <https://doi.org/10.1038/s41598-021-87649-2>
- Protopopova, A., Gilmour, A. J., Weiss, R. H., Shen, J. Y., & Wynne, C. D. L. (2012). The Effects of Social Training and Other Factors on Adoption Success of Shelter Dogs. *Applied Animal Behaviour Science*, 142, 61-68. <https://doi.org/10.1016/j.applanim.2012.09.009>
- Protopopova, A., Mehrkam, L. R., Boggess, M. M., & Wynne, C. D. L. (2014). In-Kennel Behavior Predicts Length of Stay in Shelter Dogs. *PLOS ONE*, 9, e114319. <https://doi.org/10.1371/journal.pone.0114319>
- Quadlin, N., & Montgomery, B. (2022). When a Name Gives You Pause: Racialized Names and Time to Adoption in a County Dog Shelter. *Social Psychology Quarterly*, 85, 210-235. <https://doi.org/10.1177/01902725221090900>
- Raudies, C., Waiblinger, S., & Arhant, C. (2021). Characteristics and Welfare of Long-Term Shelter Dogs. *Animals*, 11, Article 194. <https://doi.org/10.3390/ani11010194>
- Rodriguez, J. R., Davis, J., Hill, S., Wolf, P. J., Hawes, S. M., & Morris, K. N. (2022). Trends in Intake and Outcome Data from U.S. Animal Shelters from 2016 to 2020. *Frontiers in Veterinary Science*, 9, Article 863990. <https://doi.org/10.3389/fvets.2022.863990>
- Shelter Animals Count (2023). *2023 Annual Data Analysis*.

<https://www.shelteranimalscount.org/sac-releases-2023-annual-analysis/>

Shelter Animals Count (2024). *2024 Statistics*.

<https://www.shelteranimalscount.org/explore-the-data/statistics-2024/>

Svoboda, H., & Hoffman, C. (2015). Investigating the Role of Coat Colour, Age, Sex, and Breed on Outcomes for Dogs at Two Animal Shelters in the United States. *Animal Welfare*, 24, 497-506. <https://doi.org/10.7120/09627286.24.4.497>

van der Laan, J. E., Vinke, C. M., & Arndt, S. S. (2023). Nocturnal Activity as a Useful Indicator of Adaptability of Dogs in an Animal Shelter and after Subsequent Adoption. *Scientific Reports*, 13, Article No. 19014. <https://doi.org/10.1038/s41598-023-46438-9>

Walker, S. K., Powell, L., & Berliner, E. A. (2026). A Retrospective Study of Canine Outcomes and Length of Stay in a Midwestern Shelter Subject to Breed-Specific Legislation. *Journal of Shelter Medicine and Community Animal Health*, 5, Article 146. <https://doi.org/10.56771/jsmcah.v5.146>

Wells, D. L. (2021). Paw Preference as a Tool for Assessing Emotional Functioning and Welfare in Dogs and Cats: A Review. *Applied Animal Behaviour Science*, 236, Article ID: 105148. <https://doi.org/10.1016/j.applanim.2020.105148>

Zadeh, A., Combs, K., Burkey, B., Dop, J., Duffy, K., & Nosoudi, N. (2022). Pet Analytics: Predicting Adoption Speed of Pets from Their Online Profiles. *Expert Systems with Applications*, 204, Article ID: 117596. <https://doi.org/10.1016/j.eswa.2022.117596>