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Paper



Shelter Facilities And Their Role In Controlling Free-Roaming Dog Population In Abruzzo Region: A Pilot Study

Lorenzo Corsi¹, Antonio Di Nardo², Camilla Smoglica¹, Fulvio Marsilio¹, Cristina Esmeralda Di Francesco^{1*}

¹Department of Veterinary Medicine, University of Teramo, Loc. Piano D'Accio, 64100, Teramo, Italy - IT

²Unità Operativa Complessa Servizio di Sanità Animale, ASL2 Lanciano Vasto Chieti, Via Nicola Nicolini 11, 66100, Chieti, Italy - IT

*Corresponding author at: Department of Veterinary Medicine, University of Teramo, Loc. Piano D'Accio, 64100, Teramo, Italy - IT
E-mail: cedi francesco@unite.it

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Abstract

The aim of this pilot study is to identify standardised indicators useful for evaluating shelter performance in the Abruzzo region, central Italy. Data on animals admitted in 2023 and 2024 were extracted from the National Information System for Companion Animals (SINAC). A total of 2,252 dogs were analysed (1,077 in 2023 and 1,175 in 2024), and 18 active facilities were identified, with a mean capacity of 218 dogs per shelter. Most facilities had a medium (between 100 and 200 animals) or large (>200 places) capacity, while five were small (<100 places). Eight facilities (44%) were privately managed and 10 (56%) were publicly managed. The regional adoption rate increased from 45% (2023) to 49.6% (2024), while the mortality rate remained stable at 2%. The mean age at admission rose from 2.0 to 3.1 years, and the mean age at adoption increased from 1.5 to 2.4 years. The mean age at death increased from 3.4 to 6.2 years, and the average length of stay decreased from 104 to 94 days. Statistically significant differences were observed in adoption rates by sex in 2024 (χ^2 test, $p = 0.004$), among provinces (χ^2 test, $p = 0.009$ in 2023; $p < 0.001$ in 2024), and in age at adoption (Kruskal-Wallis test, $p = 0.0001$ in 2023; $p = 0.0015$ in 2024). Mixed-effects logistic regression showed shelter-level variability ($p < 0.001$) and lower odds of adoption for animals aged 1–2 years (OR = 0.53) and over 2 years (OR = 0.31). Female sex and management were associated with trends towards higher and lower probabilities of adoption, respectively, and the probability of adoption was higher in 2024 (OR = 1.45). These findings may contribute to the development of standardised performance indicators to guide resource allocation and improve shelter management.

Keywords

free-roaming dogs, shelter, adoption, Italy

Introduction

Free-roaming dogs represent a One Health issue that involves human, environmental, and animal health, and they are recognised as an issue of global concern (Cunha Silva et al., 2025; Morters et al., 2014; Silva-Rodríguez et al., 2023).

According to the World Organisation for Animal Health (WOAH), a free-roaming dog is defined as “any dog not under direct control or not prevented from roaming, including free-roaming owned dogs, free-roaming dogs without owners, as well as feral dogs”. Feral dogs are further defined as “domestic dogs that have reverted to a wild state and are no longer directly dependent upon humans” (WOAH, 2024). Therefore, the term *free-roaming dogs* refers to the condition of dogs that roam freely, regardless of their ownership status or level of socialisation, whereas the term “*stray dogs*” is used to define recently owned animals that have become lost or have been abandoned (Slater, 2001).

In Italy, dog registration has been mandatory since 1991 (Law No. 281 of 14 August 1991) and it is currently implemented through the National Information System for Companion Animals (SINAC), which brings together pet data, information, and infrastructure components for the management of free-roaming dogs and the standardisation of

operating procedures at the regional level (VetInfo, 2026). The primary objective of this legislation is to prevent dog abandonment and, consequently, to reduce the number of free-roaming dogs. For this purpose, shelter facilities constitute one of the principal instruments for the control of canine free-roaming. These facilities are organised into three categories: sanitary kennels, public rehoming shelters, and private rehoming shelters. Sanitary kennels are public initial-admission facilities, established and managed by the Public Veterinary Services which are part of the Local Health Authorities (ASLs), where veterinary care, including dog microchipping, registration in SINAC, and sterilisation, is provided by veterinary staff. Dogs are subsequently transferred to public or private rehoming shelters, established and managed by individual municipalities or associated municipalities and by private owners, respectively, where the animals remain until their adoption or death.

Overall, there are more than one thousand shelter facilities in Italy, characterised by a high heterogeneity in terms of size, facility type, management, and source of funding (public or private grants) (VetInfo, 2026). In addition, there is no official monitoring system able to evaluate the efficacy of the measures applied by each facility to improve successful adoption rates and reduce animal's length of stay, while also enabling an objective allocation of the financial resources.

Therefore, in this study data regarding the number of incoming dogs, the time of stay and shelter adoption rates in the Abruzzo region, central Italy, were analysed in relation to different parameters, including the age and sex of the animals and the capacity, type, and geographical distribution of the facilities with the aim of identifying a standardised set of indicators useful for evaluating shelter performance and improving the effectiveness of the competent authorities in managing free-roaming dogs.

Materials and methods

The analysis was based on data related to the free-roaming dog population housed in shelter facilities in the Abruzzo region during the years 2023-2024.

The Abruzzo region is located in central Italy, covering an area of 10,831 km², and is organised into four administrative provinces (Pescara, Teramo, Chieti, and L'Aquila), and 305 local municipalities with a population of 1.27 million (Figure 1).



Figure 1. Map of the Abruzzo region divided into provinces with the localization of shelters under study.

All data were extracted from SINAC (VetInfo, 2026) using the following inclusion criteria: (1) shelters located within one of the four provinces of the Abruzzo region; (2) actively operating throughout the 2023-2024 biennium; (3)

classified in the SINAC database as “*public rehoming shelter*” or “*private rehoming shelter*”. The sanitary kennels were excluded, as they represent mandatory first-admission facilities for free-roaming dogs where animals stay only for a short period of time.

The study population included only animals belonging to the species *Canis lupus familiaris* (domestic dog) that were registered as incoming to the selected free-roaming dog shelter facilities during the 2023-2024 period, with no distinction made between the different reasons for admission, such as owner surrender or legal confiscation/seizure.

The following information was collected: (1) total number of facilities; (2) number of facilities by province; (3) type of management (public or private); (4) facility size, expressed as housing capacity (maximum number of available places); (5) year of opening.

Based on housing capacity, defined as the maximum number of animals that can be accommodated, shelters were classified into three categories: large (capacity > 200 animals), medium (capacity between 100 and 200 animals), and small (capacity < 100 animals).

For each facility, the following outcome indicators were calculated: (1) number of incoming dogs per year; (2) age (years), sex and breed of incoming dogs; (3) average length of stay (days); (4) mortality rate (%); (5) mean age at death (years); (6) adoption rate (%); (7) mean age at adoption (years); and (8) sex distribution at adoption (%).

The distribution of continuous variables was assessed using the Shapiro–Wilk test. Differences among provinces were evaluated using the Kruskal–Wallis test for continuous variables and the chi-square (χ^2) test or Fisher’s exact test for categorical variables, as appropriate.

To investigate factors associated with adoption probability, a mixed-effects logistic regression model was fitted, including shelter facility as a random effect to account for clustering of dogs within shelters. Each dog represented one observation in the analysis.

The following explanatory variables were included: age class, sex, breed, shelter housing capacity, management type (public vs private), province, and year of incoming. Model fit was assessed by likelihood ratio tests comparing the mixed-effects model with a standard logistic regression model. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). Data processing and descriptive analyses were performed using Microsoft Excel, while statistical analyses were conducted using Stata v.17 (StataCorp, 2021).

Results

The total number of facilities housing free-roaming dogs that were active in the Abruzzo region during the 2023-2024 period was 18, of which 7 were located in the province of Chieti, 5 in the province of L’Aquila, 4 in the province of Pescara and 2 in the province of Teramo (Figure 1). The main characteristics of the facilities are reported in Table I. The majority of facilities were classified as either medium or large, while only 5 shelters fell into the small category. The average capacity was 218 dogs per shelter. Considering the type of management, 8 shelters (44%) were privately managed and 10 (56%) were publicly managed. The analysis of the opening dates revealed that 13 of the 18 shelters had opened before 2012.

The number of incoming dogs was 1,077 in 2023 and 1,175 in 2024, giving a total of 2,252 animals (Figure 2). The mean age at admission increased from 2.0 years in 2023 to 3.1 years in 2024.

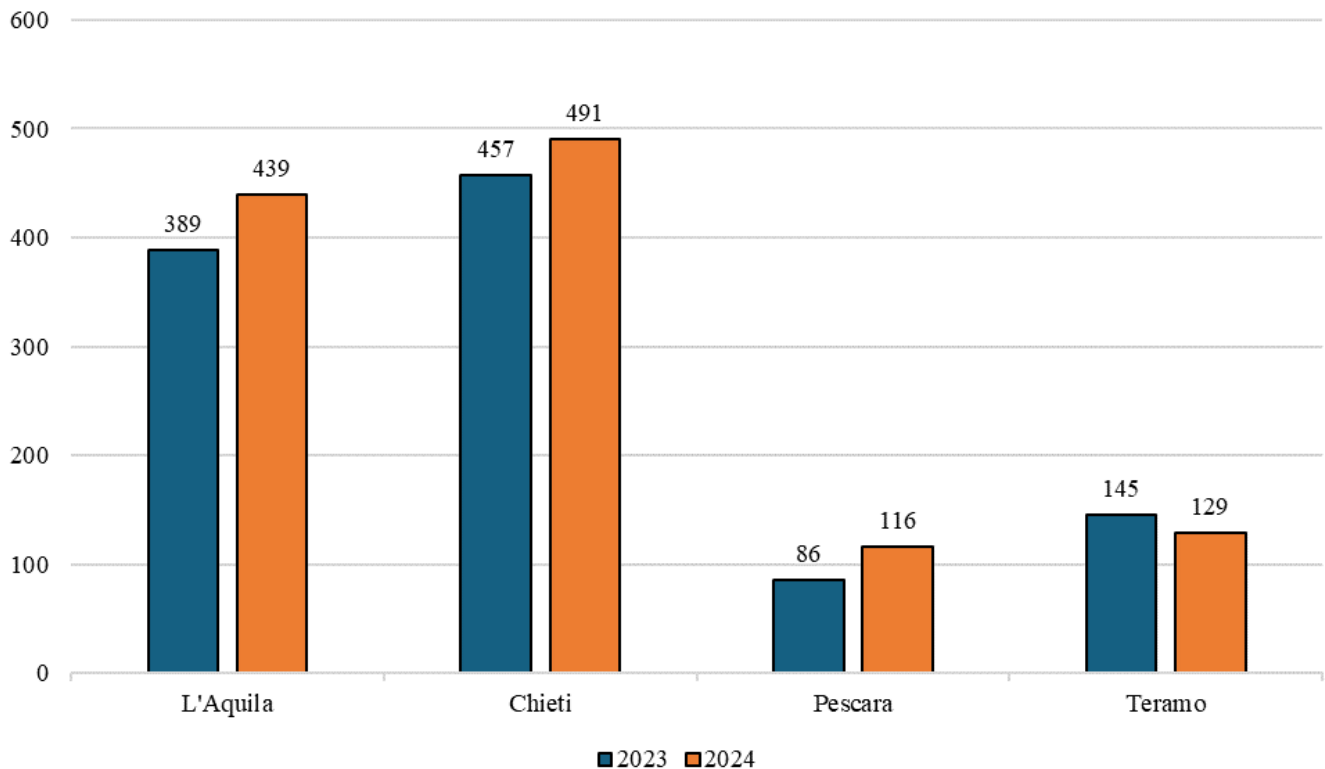


Figure 2. Distribution of all incoming dogs housed in shelter facilities in the Abruzzo region during 2023–2024, grouped by province.

The free-roaming dog population in 2023 comprised 55% (592) males and 44.6% (480) females, while for 5 dogs the sex was not specified. In 2024 there was a similar distribution with 52.1% (612) males and 47.9% (563) females.

Regarding the breed composition, the majority of animals were recorded as mixed-breed dogs in both 2023 (92.4%; 995) and 2024 (91.3%; 1,073) years. Among all admitted dogs recorded as belonging to a specific breed, the Maremmano-Abruzzese Sheepdog was the most frequent (1.6%; 17) in 2023, whereas the Pit Bull-type dogs were the most frequent (2.0%; 23) in 2024.

At the regional level, the length of stay, calculated for the total sheltered population, was 104 days in 2023 and 94 days in 2024. The details of the dog population for each province are reported in Table II, together with the p-values from the statistical analysis.

Overall, the mortality rate remained constant at 2.0% during the 2023-2024 biennium; however, the mean age at death increased from 3.4 years in 2023 to 6.2 years in 2024, in line with the increase in the mean age at admission and the decrease in the length of stay.

Considering the entire sheltered population, the adoption rate was 45.8% in 2023 and increased to 49.6% in 2024. Specifically, in L'Aquila province the adoption rate was stable, with a value of 46.3% (180/389) in 2023 and 46.5% (204/439) in 2024, in Chieti it was 47.0% (215/457) in 2023 and increased to 56.0% (275/491) in 2024, while in Teramo it was 33.8% (49/145) in 2023 and increased to 48.1% (62/129) in 2024. Conversely, in Pescara province the adoption rate was 57.0% (49/86) in 2023 and decreased to 36.2% (42/116) in 2024.

The most frequent age group at adoption was <1 year in both 2023 and 2024, with a mean age at adoption of 1.5 years in 2023 and 2.4 years in 2024.

In more detail, out of the 240 females adopted in 2023, 158 (66%) were aged <1 year, while only 37 (15%) were aged 1–2 years. Among males, 139 individuals (56%) of a total of 248 were aged <1 year, whereas only 38 (15%) were aged 1–2 years (Figure 3a). In 2024, of the 304 females adopted, 161 (53%) were aged <1 year and 34 (11%) were aged 1–2 years. Among males, out of a total of 279 adopted individuals, 138 (49%) were aged <1 year and 43 (15%) were aged 1–2 years (Figure 3b). Finally, the adoption rate among males was 41.9% (248/592), compared with 50% (240/480) among females in 2023 (χ^2 test, $p = 0.008$). In 2024, the corresponding rates were 45.6% (279/612) among males and 54.0% (304/563) among females (χ^2 test, $p = 0.004$), indicating statistically significant differences in favour of females in both years.

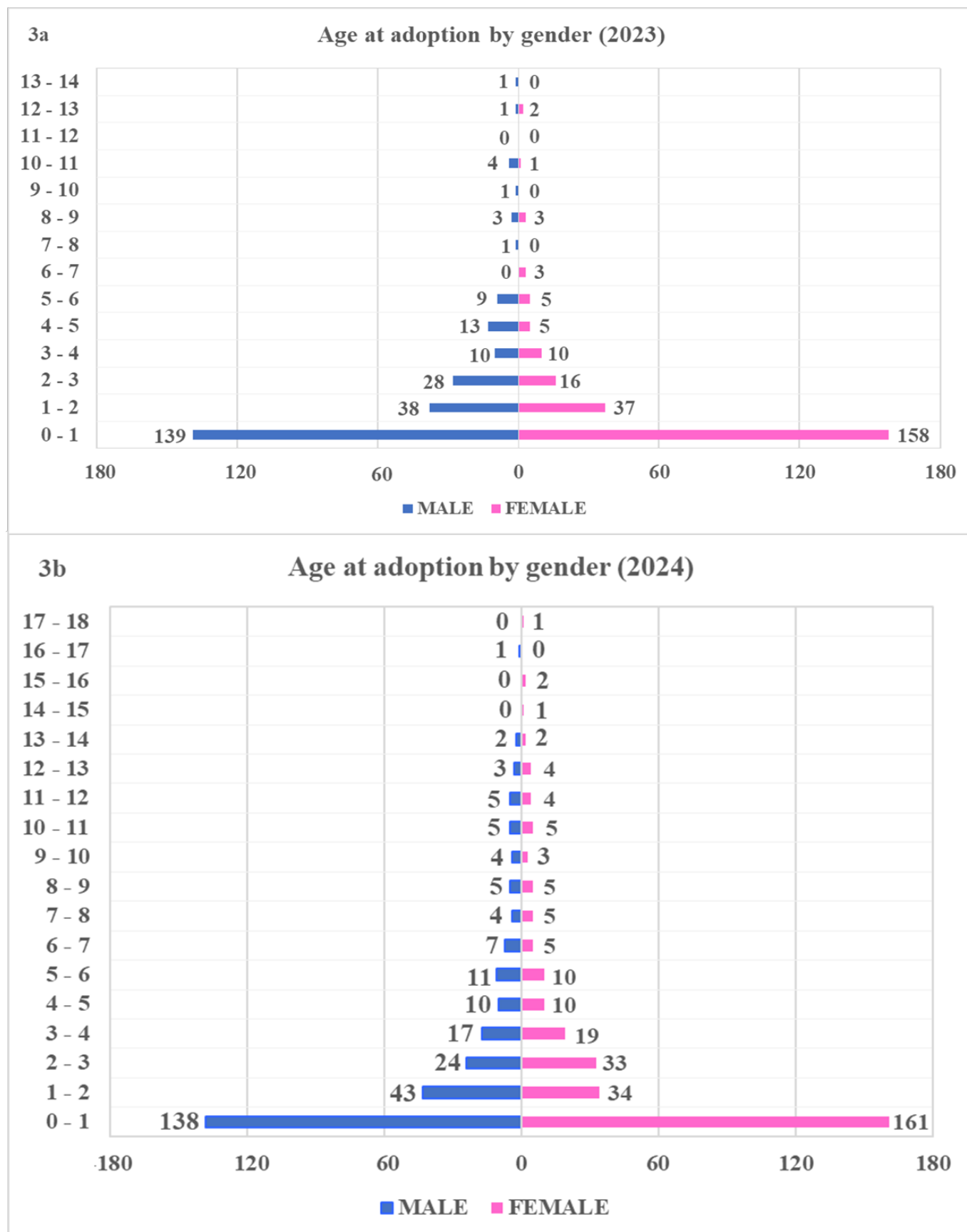


Figure 3. Trends in the age and sex distributions of dogs adopted in 2023 (3a) and 2024 (3b).

Statistically significant differences among provinces were observed in mean age at admission and length of stay in both years, and in mortality rate in 2023 only (Table II). Regarding adopted dogs, statistically significant differences were observed in adoption rates in 2023 (χ^2 test, $p = 0.009$) and 2024 (χ^2 test, $p < 0.001$), and in mean age at adoption in both 2023 (Kruskal-Wallis test, $p = 0.0001$) and 2024 (Kruskal-Wallis test, $p = 0.0015$).

In the mixed-effects logistic regression model (Table III), increasing age was strongly associated with a reduced probability of adoption. Compared with dogs aged <1 year, dogs aged 1–2 years and >2 years showed significantly lower odds of adoption (OR = 0.53 and OR = 0.31, respectively).

Female sex and private management were associated with trends towards higher and lower probabilities of adoption, respectively, but neither association was statistically significant after accounting for clustering within shelters. Regarding geographical distribution, dogs housed in Chieti province showed significantly lower odds of adoption (OR = 0.39; $p = 0.044$), whereas no significant differences were observed for Pescara and Teramo after accounting for shelter-level variability. Adoption probability was significantly higher in 2024 compared with 2023 (OR = 1.45). The random effect for shelter was statistically significant ($p < 0.001$), indicating substantial variability in adoption probability among facilities after accounting for the measured characteristics.

Shelter ID	Province	Housing capacity	Private management
n 1	PESCARA	100	NO
n 2	PESCARA	92	YES
n 3	PESCARA	70	YES
n 4	PESCARA	120	YES
n 5	TERAMO	40	NO
n 6	TERAMO	533	YES
n 7	CHIETI	160	NO
n 8	CHIETI	160	NO
n 9	CHIETI	40	NO
n 10	CHIETI	250	NO
n 11	CHIETI	140	NO
n 12	CHIETI	40	NO
n 13	CHIETI	500	YES
n 14	L'AQUILA	250	NO
n 15	L'AQUILA	120	NO
n 16	L'AQUILA	500	YES
n 17	L'AQUILA	400	YES
n 18	L'AQUILA	400	YES

Table I. List of shelter facilities included in the study and their main characteristics.

	PESCARA	TERAMO	CHIETI	L'AQUILA	p - value
Dogs admitted in 2023 (total <i>n</i> = 1,077)	86	145	457	389	n.a.
Dogs admitted in 2024 (total <i>n</i> = 1,175)	116	129	491	439	n.a.
Mean age at admission (years), 2023	2.0	2.4	2.1	1.9	0.0005
Mean age at admission (years), 2024	5.1	2.3	1.9	3.9	0.0001
Male-to-female ratio at admission, 2023	1.21	1.38	1.10	1.37	0.376
Male-to-female ratio at admission, 2024	1.03	1.11	1.02	1.17	0.750
Mean length of stay (days), 2023	90	122	97	109	0.0001
Mean length of stay (days), 2024	136	98	82	96	0.0014
Mortality rate 2023	0.00%	2.00%	1.00%	3.80%	0.021
Mortality rate 2024	1.70%	0.76%	3.20%	2.50%	0.465

Table II. Number, mean age at admission, male-to-female ratio, length of stay, and mortality rate in 2023 and 2024, by province. n.a., not applicable, as no statistical comparison was performed.

Variables	Odds ratios (95% CI) Adoption	p-value
Age class		
< 1 year	Reference	
1-2 years	0.53 (0.38-0.66)	< 0.001
> 2 years	0.31 (0.25-0.38)	< 0.001
Sex		
Male	Reference	
Female	1.18 (0.98-1.41)	0.078
Breed		
Mixed-breed	Reference	
Purebred	1.13 (0.81-1.60)	0.467
Housing capacity		
Small	Reference	
Medium	0.60 (0.20-1.79)	0.359
Large	0.59 (0.17-1.99)	0.394
Management		
Public	Reference	
Private	0.43 (0.17-1.10)	0.078
Year		
2023	Reference	
2024	1.45 (1.20-1.76)	< 0.001
Province		
L'Aquila	Reference	
Chieti	0.39 (0.16-0.97)	0.044
Pescara	1.00 (0.26-3.79)	0.995
Teramo	0.77 (0.23-2.57)	0.671

Table III. Results of the mixed-effects logistic regression model, with shelter included as a random effect to account for clustering of dogs within shelters in the Abruzzo region in 2023 and 2024. Odds ratios (ORs) and 95% confidence intervals (CIs) are reported

Discussion

In this paper, a preliminary study regarding of the free-roaming dog population, the distribution of shelters, and their structural and management characteristics was carried out in the Abruzzo region to identify factors that could influence the number of adoptions.

Previously, similar studies focused only on different parameters related to individual dog characteristics, highlighting size, age, sex, and colour of coat as factors associated with dog adoptability (Cannas et al., 2014; Normando et al., 2006; Sietto et al., 2025; Voslarova et al., 2019). Shelter characteristics, such as access to an outdoor area, the type of bedding, and the feeding regime, have been analysed to evaluate the welfare conditions of dogs housed in shelters, without considering the impact on the adoption programmes (Arena et al., 2019).

Based on these data, our study represents a first attempt to consider both animal and shelter characteristics in the evaluation of the adoption rate, suggesting a more comprehensive analysis of shelter performance.

The distribution of shelters throughout the provinces appeared to be heterogeneous, with shelters being more numerous in the provinces of Chieti and L'Aquila, probably due to their higher number of municipalities, larger territorial extent, and larger human population.

In other words, a larger human population may be associated with higher rates of animal abandonment, thus requiring a more structured system for the reception and management of free-roaming dogs. This observation further supports the hypothesis that the free-roaming dog population dynamics are closely linked to human behaviour and societal practices (Butler & Bingham, 2000; Gompper, 2021; Silva-Rodríguez et al., 2023). In this context, the presence of large-capacity shelters in more extensive territories may reflect the need to accommodate animals originating from a wider geographical area.

The adoption rate indicator represents a key parameter for assessing the capacity of shelter facilities to rehome free-roaming dogs recovered from the territory. However, the adoption rate alone is not sufficient to define service quality and should be interpreted in relation to other factors.

Although no statistically significant differences were observed for shelter variables, such as size and type of management (public or private), a trend towards improved adoptability performance seems to emerge in public shelters. This type of facility could be more efficient in the standardisation of animal management and in public relations with potential adopters.

Regarding dog's features, our results confirm that the age of animals at the time of adoption may be a relevant factor, since younger dogs (aged < 1 year) have a greater probability of being adopted (Brown et al., 2013; Cannas et al., 2014; Normando et al., 2006). Based on these results, the increase in the mean age of incoming dogs could be accompanied by a longer stay and a consequent decline in adoption performance, as observed in the province of Pescara. Conversely, in L'Aquila province, despite the increase of the main age of incoming dogs, the adoption rates remained stable between years and the mean length of stay decreased, suggesting the influence of additional management-related factors promoting adoption. Indeed, descriptive analyses highlighted differences in adoption rates among provinces. However, the mixed-effects analysis indicated that geographical variability was markedly reduced after accounting for shelter-level clustering. This finding suggests that adoption outcomes are more strongly influenced by individual facility characteristics than by the broader territorial context. For example, dogs housed in the province of Chieti still showed lower odds of adoption compared with those in L'Aquila after adjustment for age, sex, shelter characteristics and year of intake. This residual geographical effect may reflect local population dynamics, differences in the profiles of incoming dogs, or territorial adoption practices, rather than intrinsic differences in shelter performance. These results further support the importance of evaluating shelter outcomes using standardised performance indicators that account for both animal- and facility-level variability.

Another valuable indicator of service quality is the mortality rate, which should be related to the mean age at death. Very high or very low age at death, mortality peaks in specific periods, or a concentration of deaths within specific facilities may all reflect some critical aspects of health management within each shelter. Older dogs require more complex management, particularly in relation to chronic or degenerative conditions, whereas a very low age at death may indicate acute events, often of infectious origin, in puppies (Pesavento & Murphy, 2014).

Unlike what has been reported by other authors (Cannas et al., 2014; Gazzano & Iacopini, 2024), the sexes of adopted dogs were equally represented in the population under study. Females are probably perceived as being less frequently associated with aggressive behaviour in dogs, and for this reason it is considered as more suitable for adoption by people. It is remarkable that all dogs under study, regardless of sex, are neutered by the veterinary staff of

sanitary kennels, and this practice could have influenced our results. However, the existing literature does not allow a single, univocal conclusion regarding the effects of neutering on canine behaviour. Some studies have reported that surgically castrated dogs do not show a significant reduction in sexual activity or aggressive behaviour when compared with their pre-intervention status (Garde et al., 2016). Conversely, earlier studies recommended neutering, especially in males, as an effective strategy to reduce certain undesirable behaviours such as roaming, mounting, urinary marking, and intermale aggression (Hopkins et al., 1976; Knol & Egberink-Alink, 1989; Maarschalkerweerd et al., 1997; Neilson et al., 1997). This perspective still largely reflects current public perception regarding the association between neutering and the reduction of aggressive behaviour (Downes et al., 2015). Such owners' perceptions are also supported by more recent surveys, in which pet owners reported reductions in aggressive behaviours towards other dogs and animals, as well as decreased roaming, mounting, urine marking, and overall activity levels following neutering (Kriese et al., 2022). Considering these findings, the adoption of public communication strategies, grounded in the most recent scientific evidence, appears particularly important, especially regarding the substantial amount of conflicting information currently available on this topic. Recent studies on canine behaviour emphasise its multifactorial nature, highlighting the complexity of interpreting outcomes following neutering. Intrinsic factors such as sex, breed, age, body weight, and size, together with extrinsic influences including the owner's lifestyle, personality, demographic characteristics, cultural background, and societal values, all contribute to the development of a dog's individual profile. Given this complexity, establishing a direct causal relationship between neutering and post-surgical behavioural changes remains challenging (Arroubé & Pereira, 2025).

Apart from the sex of adopted dogs, the adoption probability appears to be positively influenced by the behavioural characteristics of housed dogs and by social enrichment. For example, exercise and walking areas in shelter facilities can help improve animal welfare and reduce aggressiveness (Arena et al., 2019; Menor-Campos et al., 2011). More specifically, appropriate dog training programmes in shelters, provided by veterinary staff or other technical behaviourists, may increase the chances of adoption for older or male dogs (d'Angelo et al., 2022). Indeed, the significant random effect observed for shelters supports the hypothesis that management practices, enrichment strategies, and local organisational factors may substantially influence adoption outcomes beyond individual dog characteristics.

Some limitations of this study concern the reliability of data recorded in the SINAC database, mainly due to the difficulties in obtaining complete and reliable data for some facilities, which were therefore excluded from the analysis, and for dogs admitted to shelters before 2023. These difficulties may be attributed to two main factors. First, keeping the database continuously updated requires considerable effort from shelter staff, and this effort may be lacking, especially in small shelters. Second, the SINAC system is a national database recently established by Italian legislation (Ministero della Salute, 2023) and, for some regions, the migration of data from local previous database is currently in process. For these reasons, the analyses were restricted to incoming dogs only, limiting the study period to 2023-2024 years.

Conclusion

The present study represents a first attempt to develop a set of numerical indicators to define the level of the services supplied by each shelter. The approach proposed may contribute to the development of a standardised evaluation system to support the administrative management of free-roaming dogs, and to orient the future distribution of public or private financial resources. Grant allocation based on objective performance indicators could support the most effective facilities, promote continuous improvement of the services provided, and ensure a fairer and more efficient use of available resources.

In conclusion, it should be remembered that the evaluation of facilities has important implications for public health, animal welfare, the environment, and quality of coexistence between humans and animals. For this reason, the perspectives opened by this study also highlight the responsibility of institutions to promote increasingly transparent and effective management policies aimed at continuous improvement.

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Ethical approval

This study did not require ethical approval because it involved the analysis of data extracted from previously published studies, and no new human or animal subjects were involved.

Conflict of interest

No potential competing interest was reported by the authors.

Author Contributions

Conceptualisation: ADN, FM; Methodology: LC, ADN, CS, CEDF; Formal analysis: LC, CS; Investigation: LC; Writing original draft preparation: LC; Writing, review and editing: ADN, CS, CEDF, FM; Visualisation: LC, CS; Supervision: ADN, CEDF, FM; Project administration: CEDF, FM; Funding acquisition: Not applicable.

All authors have read and agreed to the published version of the manuscript.

Data availability

All data available upon request to the corresponding author.

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Department of Economics and Sustainable Development, Harokopio University of Athens, Athens, Greece, Sietou, A. S., Theodoropoulou, E., Department of Economics and Sustainable Development, Harokopio University of Athens, Athens, Greece, Karagianni, V., Department of Tourism Management, University of West Attica, Athens, Greece, Sossidou, E., Research Director of Elgo Demeter, Thessaloniki, Greece, Sietou, C., & Department of Agricultural and Environmental Sciences Division, School of Biosciences, University of Nottingham, Nottingham, UK. (2025). Adoption Preferences of Greek Citizens in Stray Dogs: The Role of Morphological Characteristics. *World's Veterinary Journal*, 15(1), 162–166. <https://doi.org/10.54203/scil.2025.wvj18>

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