SMALL ANIMALS

Assessment of stress levels among cats in four animal shelters

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Objective—To measure stress levels among cats in traditional and enriched shelter environments via behavioral assessment and urine cortisol-to-creatinine ratios.

Design—Cross-sectional observational study.

Animals—120 cats in 4 Boston-area animal shelters.

Procedure—Cats were randomly selected and observed during 3 periods (morning, midday, and afternoon) of 1 day and scored by use of a behavioral assessment scale. The next day, urine samples were collected for analysis of the urine cortisol-to-creatinine ratio. Information about each cat's background before entering the shelter was collected.

Results—Stress scores were highest in the morning. The relationships between the amount of time cats spent in the shelter and the cat stress score or urine cortisol-to-creatinine ratio were not strong. There was no correlation between the cat stress score and urine cortisol-to-creatinine ratio. Urine cortisol-to-creatinine ratios did correlate with signs of systemic disease and were significantly lower in cats in the more environmentally enriched shelters, compared with cats in the traditional shelters. Urine cortisol-to-creatinine ratio was highest among cats with high exposure to dogs. Of the cats in the study, 25% had subclinical hematuria detectable on a urine dipstick.

Conclusions and Clinical Relevance—In this study, the cat stress score was not a useful instrument for measuring stress because it failed to identify cats with feigned sleep and high stress levels. Urine cortisol-to-creatinine ratios can be monitored to noninvasively assess stress levels in confined cats. Environmental enrichment strategies may help improve the welfare of cats in animal shelters. (*J Am Vet Med Assoc* 2005;226:548–555)

Confinement in an animal shelter is an extremely stressful experience for cats. The shelter environment presents a far more restricted living condition than that associated with either a free-ranging lifestyle or a private home. In shelters, an altered routine, as well as interactions with unfamiliar people, animals, and environment, coupled with separation from familiar surroundings may be stressful for cats.[1] In 1 study,[2] most cats became adjusted to a shelter environment within 2 to 5 weeks, but some never adjust to confinement and remain distressed for months.[3] Captive (confined) environments can be particularly stressful because they provide limited opportunity for the active behavioral responses that normally enable coping with an aversive situation.[4] Reducing the stress experienced by cats in shelters would be likely to improve their welfare and tractability, thus increasing their potential for adoption and possibly improving their behavior in the postadoption period.

Thus, animal shelters have many incentives for striving to maximize the welfare of shelter animals. Although it is true that the absence of physiologic stress does not guarantee psychologic well-being,[5] excessive stress or distress can be debilitating. Clinical signs of stress include generalized disruptions of normal physiologic function, such as alterations in feeding behavior, hypertension, gastric and intestinal ulceration, electrolyte imbalance, urticaria, and immune deficiencies.[6] Therefore, the ability to define and measure stress in animals offers a defensible means of assessing animal well-being.[7]

Plasma cortisol concentration is frequently measured as an indication of a stress response in humans and nonhuman animals.[1,6,8-10] However, blood collection is invasive; therefore, anticipatory reactions and responses to sample collection may bias findings and lead to misinterpretation of data.[11] A noninvasive measure that has been used to assess stress levels in domestic cats is the urine cortisol-to-creatinine concentration ratio. The concentration of cortisol in a urine sample reflects the mean plasma cortisol concentration during the time in which that urine was produced.[12] The usefulness of urine cortisol analysis for evaluation of adrenal responses to stressors has been revealed in a host of species and validated in both domestic and nondomestic felids living in shelters or similar institutional environments.[4,13-15]

Another approach to stress measurement is behavioral assessment.[2,16,17,a] Manifestations of abnormal behavior can indicate how successfully an animal is coping with its environment, as behavior reflects internal states.[5] A 7-level cat stress assessment scale or cat stress score **(Appendix)** has been developed and used in several studies[2,16,17] to measure stress levels among confined cats. A cat stress score could be useful because it involves detailed descriptions of behavioral and postural signs of stress, which should help distinguish between stressed and nonstressed cats quickly and noninvasively. Several studies have compared urine cortisol-to-creatinine ratios to observations of behavior, but to the authors' knowledge, none have formally compared this physiologic measure to the cat stress score.

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It is important to develop methods for monitoring the well-being of confined animals so that caretakers can intervene to improve animal welfare when necessary. Behavioral measurement scales are widely viewed as subjective and are usually not accepted as a valid indication of stress unless accompanied with physiologic data. Although a combination of physiologic and behavioral data provides the best evidence of psychologic stress,[18] personnel in many animal shelters will not have the resources to obtain physiologic data. Therefore, having an easy-to-use observational assessment scale such as the cat stress score would prove valuable. The purpose of the study reported here was to evaluate stress levels among cats in traditional and enriched shelter environments via behavioral assessment and monitoring of urine cortisol-to-creatinine ratios. It was hypothesized that cats in the more environmentally enriched settings would have lower levels of stress.

Materials and Methods

The research protocol for this project was approved by the Tufts University School of Veterinary Medicine Institutional Animal Care and Use Committee.

Study sites—To obtain data on cats exposed to a wide variety of shelter housing, 4 shelters, each containing several different types of housing conditions, were included in the study. The study sites included 2 large animal shelters in Boston with a traditional shelter design (shelters with floor-to-ceiling metal cages lining the walls of a room) and 2 shelters located some distance from Boston that featured more progressive design features. Shelters from 2 independent humane society organizations were used.

Site 1 was an urban shelter with a traditional design. The cats were housed in 2 areas: an adoption floor, which had traditional cages located next to a dog adoption area, and a holding area, which also featured traditional metal cages. At site 1, approximately 1,500 cats are accepted each year (127 cats/mo); during the month in which the study was conducted (June 2002), 162 cats were accepted into the shelter. There were 8 designated animal caregivers at site 1.

Site 2 was a large urban shelter that was built in 1957. The cats in this shelter were housed in traditional steel cages. The holding area was divided into several smaller rooms, some of which also housed dogs. At site 2, approximately 5,500 cats are accepted each year (450 cats/mo); during the study period, the mean daily census of the facility was 120 cats. There were 10 designated animal caregivers employed at site 2.

Site 3 was a modern suburban shelter, which opened in June of 2002. The facility was specifically designed to provide a lower stress environment for animals. The adoption area featured natural light on 2 sides, and the lowermost cages were positioned approximately 0.5 m (2 to 3 feet) above the floor. The holding areas featured elevated cages with perching shelves. Cats were provided with a window for exposure to natural light, and dogs were not housed within the same wing as cats. At site 3, 1,053 cats were accepted in 2002 (150 cats/mo); during the study period, the mean daily census was 55 cats. There were 6 designated animal caregivers employed at site 3.

Site 4 was located in an urban center but served a large surrounding rural community. The facility in use during the study period was built in 1998. Features for stress reduction included soundproof walls, natural light exposure, and variable orientation of cages to prevent visual access to other cats. At site 4, approximately 6,800 cats are accepted each year (560 cats/mo). There were 8 designated animal caregivers employed at site 4.

Sites 1 and 2 represented traditional housing for cats, whereas sites 3 and 4 represented enriched environments. All 4 sites had several locations for housing cats within the facility. In general, cats newly entering a shelter facility are held in a holding area for variable periods of time before being moved to an adoption area. Cats within an adoption area are exposed to the public for some period of the day and are available for adoption. Cats in holding areas are typically not on display and are not available to be adopted. A cat's duration of stay in a holding area before being moved to the adoption floor depends (among other factors) on the personality and health status of the particular cat, the number of cats already in the facility, and regulations regarding holding times of stray animals, which vary by community.

After completion of all behavioral observations in the study, the noise level and extent of dog occupancy of the holding and adoption areas of each site were subjectively classified by 2 of the authors (ECM and AM). A shelter area was considered to have a high dog-exposure level if there were dogs in the area or if dogs could be easily heard or were walked through the area. Areas in which the noise level was consistently loud throughout the day were designated as high-noise areas; areas that tended to remain quiet after the morning cleaning period were designated as low-noise areas

Cats—From each shelter population at each of the 4 study sites, cats were randomly selected for inclusion in the study by numbering their cages and use of a random number generator. Cats that were under quarantine were excluded, but otherwise, cats from both adoption and holding areas were included in the study. If a randomly chosen cage did not contain a suitable subject (eg, it contained a kitten or multiple cats), the next cage on the list was used. Only singly housed cats > 9 months of age were included in the study.

Behavioral assessment—On the morning of the first day of data collection, the cats were selected and the cages labeled to alert staff to their inclusion in the study. By use of the observational cat stress scoring system reported by Kessler and Turner[16] (Appendix), each cat was assigned a score by 1 of the investigators (ECM). According to this scoring system, a cat that appeared to be fully relaxed would be assigned a score of 1.0, whereas a cat that appeared to be highly stressed would be assigned a score of 7.0. For example, a cat who was alert and eating, with its ears up, would be assigned a score of 3.0 to 3.5 by use of this system. If a cat's postures fit more than 1 score category, the category that seemed to fit the best was chosen. If the results were split between 2 categories, then a half score was assigned (eg, if half of the body parts was assessed as score 5.0 and half was assessed as score 6.0, the cat would be assigned a score of 5.5). Each cat was observed within its cage for approximately 5 minutes before the score was assigned. After an interval of at least 15 minutes (during which time the investigator moved on to score other cats), each cat was scored again. This entire scoring process was conducted at 3 separate times at approximately 8 AM (generally during morning cleaning), 12 PM, and 4 PM. For each time period, the mean of each cat's 2 scores was calculated to provide a single stress score.

Urine collection and analysis—On the first day of data collection, each cat selected for the study was provided with a litter box containing nonabsorbable litter pellets.[b] On the second day of the study, any urine and fecal samples voided by the cats were collected. The urine was tested for protein and glucose by use of reagent strips.[c] From each cat that had urinated, a minimum of 5 mL of urine was collected and the sample was submitted to a veterinary diagnostic laboratory[d] for determination of the urine cortisol-to-creatinine ratio. For cats that had not urinated during the first 24 hours of the data collection period, nonabsorbable cat litter was left in the cage for an additional 24-hour period, after which samples were again collected. After 48 hours, the cats were released from the study and were provided with litter pans containing regular litter, even if they had not provided a urine sample for the study.

Additional data—On arrival at each site, the shelter's computer system[e] and intake forms were used to record information about each cat; the cat's age, sex, reproductive status, and breed were recorded as well as any information about the cat's lifestyle before entering the shelter that was provided by the person bringing the cat in. On the second day of data collection (after all behavioral data had been collected), a physical examination was performed on each cat by one of the investigators (ECM) and any information about health status was recorded. After several months, the outcome for each cat (ie, adoption, euthanasia, return to owner, or placement in foster care) was researched through computer records. The chances of a cat being adopted or euthanatized were not affected by its participation in the study, and the staffs of the shelters were unaware of any cat's study scores.

Statistical analyses—Data were entered into a commercial software package[f] that was used to generate descriptive statistics. The χ^2 test was used to evaluate statistical associations between categorical variables, and the independent *t* test was used for continuous variables. An ANOVA was used to compare > 2 group means and to test for significant interactions among variables.[19] A value of $P < 0.05$ was considered significant.

Results

At each of the study sites, the mean age of the cats was similar (between 2 and 3 years; **Table 1**). Among the 120 cats, 70 (58.3%) were females, of which 37 (52.8%) were spayed. Fifty of the 120 (41.7%) cats were males, of which 26 (52%) were neutered. Overall, 63 of 120 (52.5%) cats were either spayed or neutered. For all 120 cats, the mean number of days spent in the shelter was 12.7 (median, 7 days). Compared with the other sites, cats at site 4 spent less time in the shelter (mean duration of stay, 5.9 days; median, 4 days), although this difference was not significant ($P = 0.07$). Eighty-three of 120 (69.2%) cats were surrendered to the shelter by their owners, whereas 37 of 120 (30.8%) cats were stray cats.

Outcome—Sixty-seven of 120 (55.8%) cats were adopted, whereas only 37 of 120 (30.8%) cats were euthanatized. One cat was still in the shelter by the end of the study. Three cats had been placed in foster homes, and 5 cats were transferred to other shelter facilities. Two of the 120 study cats had been returned to their original owners by the end of the study. Information about the outcome was not available for 5 cats.

The 4 sites differed from each other with respect to adoption rates. The adoption rate at site 1 was 82.4%, whereas at site 3, it was only 37.9%. The other 2 sites had comparable adoption rates of 55.2% and 42.9%.

Behavioral assessment of stress—The stress scores for the study cats ranged from 2.0 to 6.0 (possible score range, 1.0 to 7.0; **Figure 1**). As measured by use of the behavioral assessment scale, stress levels among cats were highest at the morning evaluation (mean morning stress score, 3.31) and then decreased at each following evaluation. The greatest decrease in stress scores occurred between the morning and midday evaluations (mean midday stress score, 2.90); the mean afternoon stress score was 2.83, which was not significantly ($P = 0.26$) different from the midday value. Of the 3 evaluation periods, there was considerably more variability among stress scores recorded during the morning evaluation, but a small number of extremely stressed cats had high scores at each evaluation period. The results for the morning evaluation were used for additional analyses because this period provided the most variability among stress scores.

There was a slight negative correlation ($r = -0.18$; $P = 0.04$) between the number of days a cat had spent in the shelter and its morning stress score (**Figure 2**). The cats that had been in the shelter the longest were usually less stressed. There was considerably less variability among stress scores as the cats spent longer periods of time in the shelter. There was no difference in mean morning stress score between cats who were surrendered by their owners and those that were brought to the shelter as strays. Although there was little difference ($P = 0.50$) between the mean morning stress scores for cats who were euthanatized and cats who were adopted, cats assigned high scores by use of the behavioral assessment scale were more likely to be euthanatized. Of 9 cats who scored 4.5 or higher, 5 were euthanatized, compared with 32 of 111 cats who scored lower than 4.5. However, this difference was not significant ($P = 0.1$).

The mean morning stress score of cats in adoption areas (score, 3.12) was significantly ($P < 0.01$) lower than the mean stress score of cats in the holding areas (score, 3.45). Compared with the holding area populations, more of the lowest-scoring cats were located in the adoption areas. In contrast, all of the cats with the high-

Table 1—Characteristics of 120 cats in 4 animal shelters that were evaluated for stress via behavioral assessment and determination of their urine cortisol-to-creatinine ratio.

	Shelter site				
Variable	**1**	**2**	**3**	**4**	**Total**
No. of cats (%)	34 (28)	29 (24)	28 (23)	29 (24)	**120 (100)**
Age (y)					
Mean	3.3	2.1	3.0	2.3	**2.7**
Median	2.25	2.00	2.00	1.50	**2.00**
Sex					
Spayed female	21	3	11	2	**37**
Sexually intact female	3	12	7	11	**33**
Neutered male	7	3	8	8	**26**
Sexually intact male	3	11	2	8	**24**
Intake category					
Surrendered by owner	27	15	22	19	**83**
Stray	7	14	6	10	**37**
Time spent in shelter (d)					
Mean	15.5	14.4	14.5	5.9	**12.7**
Median	7	9	12.5	4	**7**

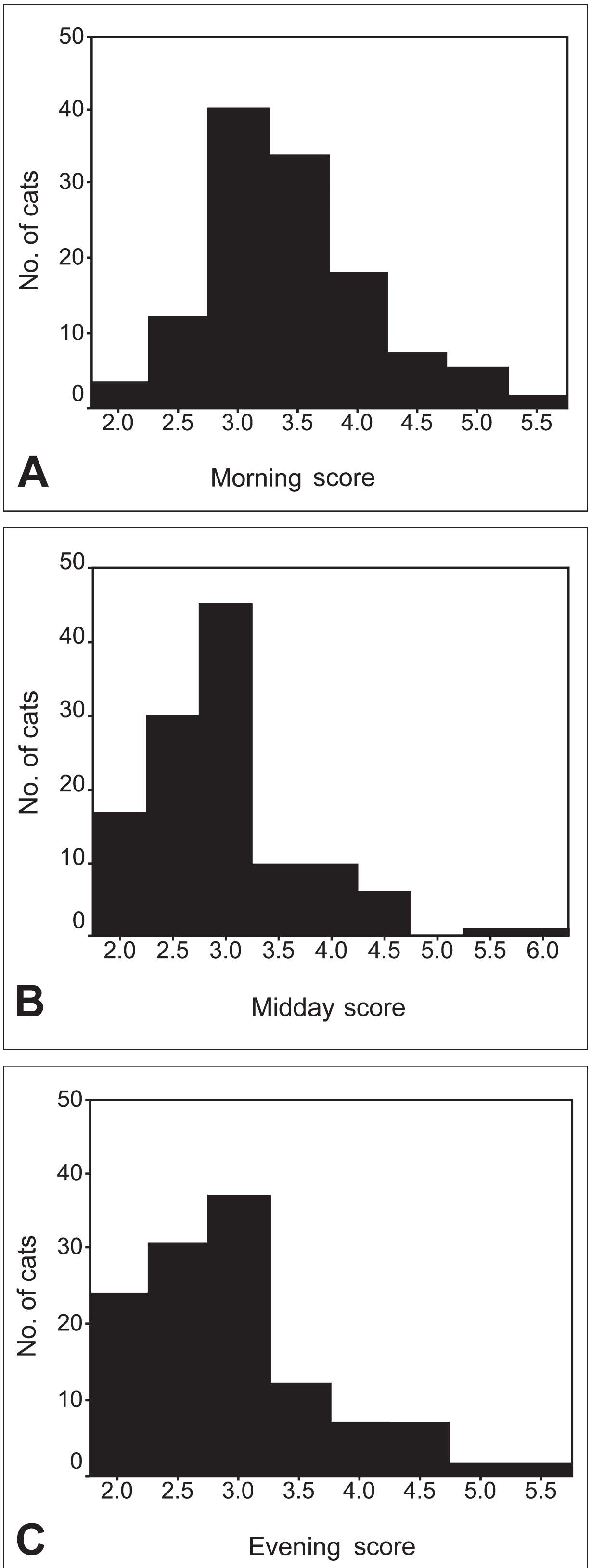

Figure 1—Distribution of the stress scores assigned to 120 cats in 4 animal shelters by use of a behavioral assessment scale during morning (A), midday (B), and evening (C) evaluations. High scores represent high stress levels among cats (maximum score, 7.0).

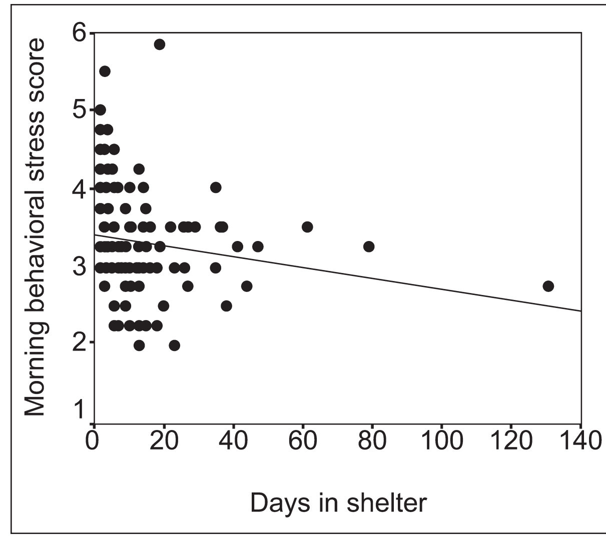

Figure 2—Relationship between the morning stress score assigned by use of a behavioral assessment scale and the days spent in the shelter for each of 120 cats in 4 animal shelters. The correlation coefficient (*r*) is 0.18.

est stress scores were located in the holding areas. By use of the behavioral stress score system, there were no significant differences in morning stress scores among cats at the 4 different sites, although cats at site 2 had slightly lower stress scores than the cats at the other 3 sites.

Physiologic stress—Urine cortisol-to-creatinine ratios were determined for 97 of the 120 (81%) study cats. The urine cortisol-to-creatinine ratios ranged from 1.0 to 48 (mean urine cortisol-to-creatinine ratio, 6.8; median ratio, 5.0). Laboratory standards defined the upper limit of the reference range as 13.5; in unstressed individuals, values higher than this are indicative of hyperadrenocorticism. Most of the study cats' urine cortisol-to-creatinine ratios were within the reference range; however, 12 cats had urine cortisol-to-creatinine ratios > 13.5.

For analysis, the natural log (ln) of the urine cortisol-to-creatinine ratios was used to normalize the data. There was no correlation ($r = 0.07$) between the urine cortisol-to-creatinine ratios and the mean morning stress scores. There was almost no correlation ($r = -0.09$) between the number of days that a cat had spent in the shelter and its stress level as indicated by the urine cortisol-to-creatinine ratio **(Figure 3)**. Compared with other cats, there was considerably more variability in urine cortisol-to-creatinine ratio among cats that had spent ≤ 3 days in the shelter.

Physiologic stress levels did not differ significantly among stray or surrendered cats, by outcome category, or by the area of the shelter in which the cats were housed. There were no differences in urine cortisol-to-creatinine ratios according to these factors, even when cats that had been in the shelter longer than 19 days were excluded from analysis. Stress levels as measured by urine cortisol-to-creatinine ratio were actually slightly higher among cats that were adopted than cats that were euthanized, although this difference was not significant. Cats that were from multiple-cat households had slightly higher ($P = 0.05$) urine corti-

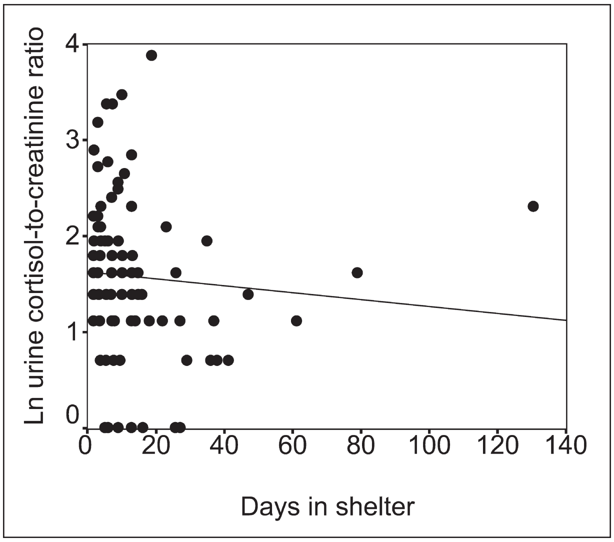

Figure 3—Relationship between natural log (ln) of urine cortisol-to-creatinine ratio and the days spent in the shelter for each of 97 cats in 4 shelters. The correlation coefficient (*r*) is –0.09.

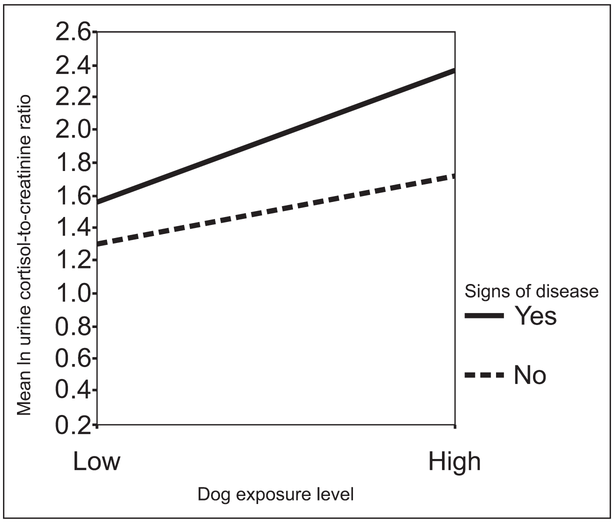

Figure 4—Plot of mean ln of urine cortisol-to-creatinine ratio versus level of exposure to dogs for 97 cats at 4 animal shelters. The solid line represents cats with signs of systemic illness, and the dotted line represents cats without signs of disease.

sol-to-creatinine ratios (mean ratio, 8.3) than cats that were from single cat homes (mean ratio, 4.9).

Other factors affecting stress level—Cats at sites 1 and 2 had significantly (*P* = 0.015) higher urine cortisol-to-creatinine ratios (mean ratios, 8.83 and 9.32, respectively; *P* value reported from transformed data) than did cats at sites 3 and 4 (mean ratios, 4.63 and 4.42, respectively). At sites 1 and 2 (which represent the urban, traditional shelter-design sites), there was a negative correlation (*r* = –0.35; *P* = 0.004) between the cats' stress levels (as assessed by use of the behavioral assessment scale, but not as assessed by determination of the urine cortisol-to-creatinine ratio) and the days that they had been in the shelter. Conversely, at sites 3 and 4 (which represent the rural, more environmentally enriched shelter sites), there was a negative correlation (*r* = –0.32; *P* = 0.027) between urine cortisol-to-creatinine ratio and the number of days that the cats had been in the shelter.

Of 120 cats in the study, 29 (24.2%) had signs of systemic illness, such as upper respiratory tract disease, vomiting, or diarrhea. Additionally, of the 98 cats from which urine was collected, 25 (25.5%) had evidence of hematuria. There was a significant (*P* = 0.001) difference in urine cortisol-to-creatinine ratios between cats that had signs of systemic disease (mean ratio, 5.80) and those that appeared to be healthy (mean ratio, 10.32; *P* value reported from transformed data).

The specific shelter environments were analyzed for factors that could affect stress levels in cats. There was no significant relationship between noise level in the shelter and stress level in cats as assessed by use of the behavioral assessment scale or by determination of urine cortisol-to-creatinine ratio. Among the study cats, there was also no relationship between dog exposure and the behavioral stress score. However, cats with high dog-exposure levels had significantly (*P* = 0.04) higher urine cortisol-to-creatinine ratios, compared with values for cats with low dog-exposure levels. Increasing level of dog exposure also increased urine cortisol-to-creatinine ratios among cats that had clinical signs of systemic disease (**Figure 4**).

Discussion

To our knowledge, the present study is the first in which the distribution of urine cortisol-to-creatinine ratios among a population of shelter cats has been characterized and the results had considerable variability. Despite conscientious monitoring and attentive care of these cats by shelter staff, there were other indicators of adverse welfare or stress among the study cats. For example, almost 25% of the cats in the study had signs of systemic illness. Additionally, > 25% of the urine samples obtained from the study cats contained at least trace indications of hematuria. Because feline idiopathic cystitis has previously been postulated to be a stress-related condition,[20] it is possible that this finding may be further evidence of chronic stress among shelter cats.

A previous study[15] in which urine cortisol-to-creatinine ratios in cats were investigated revealed that cats in quarantine environments generally adapted to their surroundings over a period of 5 weeks. Because animal shelters are not likely to keep cats in their facilities for more than a few days to a few weeks, it was not possible to design a study that would follow individual cats in animal shelters for a comparable period. Although individual cats were not monitored over time in the present study, our data did not indicate a relationship between urine cortisol-to-creatinine ratio and the number of days spent in the shelter for any particular cat. This finding may indicate that some of the cats included in our study were not adapting to the shelter environment. Given the potential adverse health consequences of chronic stress and the fact that cats may not experience a decrease in their shelter-associated stress levels with time, it is important for animal shelter personnel to take steps to reduce the amount of stress in their cat populations.

There was a slight indication that stress (as assessed by use of the behavioral scale) did decrease with time in the urban or traditional shelters. This was a weak relationship. One explanation is that cats that spend longer periods of time in the shelter may develop signs of depression such as increased time spent sleeping. In fact, hiding and feigned sleep are part of a passive defense syndrome common to cats and other carnivores that are kept in zoos.[13] The cat stress score is limited because all cats that appear to be sleeping will generally be assigned a low score, irrespective of their true emotional state. Failure to adapt to the environment in urban shelters could also explain the lack of a correlation of the physiologic measure of stress with time in those shelters. Conversely, in the enriched shelters with environments more conducive to cats' needs, the physiologic measure of stress did decrease with time.

The results of the present study indicated that neither behavioral nor physiologic stress was related to the outcome for the cat (ie, adoption vs euthanasia). Although this may be a consequence of limitations in the study (in that individual cats were evaluated at different times during their stay, so their stress levels may not have been similar at the times at which the decision to euthanatize certain cats was made), it may also suggest that much of the cat population of the shelter might be expected to be affected by chronic stress. Despite the fact that a few highly stressed cats are usually removed from the shelter early in their stay (through euthanasia or transfer to a foster home), the effects of the chronic stress on a newly adopted shelter cat in its new home are as yet unknown. Further study is needed to monitor the stress levels of individual cats over time and to determine the effects on the animals' overall quality of life.

Previous studies have correlated urine cortisol-to-creatinine ratios with behavioral assessments. For example, Rochlitz et al[15] detected a decrease in urine cortisol-to-creatinine ratio that coincided with a decrease in observed hiding behavior (recorded by use of a video camera) among cats housed in a quarantine cattery. Similarly, Carlstead et al[14] classified laboratory cats as stressed or unstressed through the use of urine cortisol-to-creatinine ratios; among the stressed cats, activity levels were lower. However, in the study of this report, no correlation between behavioral stress assessment and the physiologic measure of stress was identified. This lack of correlation could possibly be explained by the fact that the cat stress score may systematically underestimate cat stress levels because passive or inactive cats are generally assigned a low score. For example, when applying the cat stress score, cats that are sleeping, have closed eyes, or have a relaxed posture are all assigned a low score. Thus, the cat stress score may not be useful in a shelter situation, at least when applied as it was in our study. This assessment tool may be more useful if the investigator interacts directly with the cats in the shelter to avoid the potential to confuse sleep or feigned sleep with an unstressed state. An evaluation of stress that involves interactions with individual cats would be more similar to the manner in which shelter workers empirically evaluate cats in their care.

However, the lack of correlation between the behavioral and physiologic measures could also possibly be explained by the inability to control for the highly variable housing conditions for individual cats in our study. Variable environmental conditions (eg, particular times of the day when it was noisy) might be expected to affect the behavioral assessment scores to different extents, depending on what was occurring at the time that the cat was evaluated. In contrast, physiologic measures such as urine cortisol-to-creatinine ratios are known to be more cumulative and reflect the mean stress level of the cat during the period in which the urine was produced.

Thus, the lack of correlation between the behavioral stress assessment and the physiologic measure of stress might be explained by the fact that the latter (urine cortisol-to-creatinine ratio) was cumulative and the former (stress score) was more dependent on environmental conditions at the time of evaluation. As evidence for this phenomenon, in the environmentally enriched shelters, the cumulative measure of urine cortisol-to-creatinine ratio was negatively correlated with the number of days that the cats had been in the shelters. This may indicate that cats were better able to acclimate to the environmentally enriched shelters than to traditional shelters. In contrast, at the traditional shelters, the behavioral stress score of cats correlated with the duration of stay at the shelter. The behavioral assessment scale is likely to be a less sensitive indicator of feline stress than urine cortisol-to-creatinine ratio. Therefore, behavior must become extreme for stress to be detectable. We believe that it was more difficult for cats to adapt to conditions at the traditional shelters, allowing for the expression of more extreme forms of stress-related behaviors.

Interestingly, the biggest factor affecting the cats' stress levels in the different types of shelter housing appeared to be the extent of exposure to dogs. Cats in areas of high dog exposure had higher stress levels than did cats in areas with high noise levels. Furthermore, the effect of the presence of dogs appeared to be additive, in that it increased stress levels more for cats who were obviously ill than for cats that had no signs of disease, although this interaction was not highly significant.

In recent years, many animal shelters have begun to redesign shelter facilities with the intent to reduce shelter animal stress levels. Design features thought to improve the quality of life for shelter cats include improvement in the quality of soundproofing, which isolates cats from the sounds of barking dogs and other noises; exposure to windows and other sources of natural light; provision of hiding and perching areas; and elevation of cats' cages above the floor, which is believed to make them feel safer.[3] The sites in our study included an older and a newer shelter from each of 2 animal rescue organizations. In the design of the newer of their shelters, both organizations had incorporated features that were specifically designed to reduce the stress of feline occupants. For example, site 3 featured cages that were elevated several feet off the ground and all included a perching shelf; additionally, all of the cat housing at site 3 provided exposure to natural light. Site 4 also had more elevated cages than traditional shelters, and the cages were arranged so that the cats typically did not face one another. There were windows into all of the rooms that housed cats and the walls were insulated to provide soundproofing. Reassuringly, as determined by the use of urine cortisol-to-creatinine ratios, the cats in the newer more enriched shelters (sites 3 and 4) had significantly lower stress levels than cats in the traditional or unenriched shelters (sites 1 and 2).

Another trend in housing design in new shelters has been the incorporation of multiple-cat housing. It has increasingly been recognized that cats have a unique social structure and that housing them in social groupings can provide an important source of enrichment. In our study, cats that had originated from multiple-cat households had higher stress levels than cats that had been singly housed prior to entering the shelter. Because the study only included cats that were caged singly, this finding may indicate that separating cats from their housemates does increase their stress and appears to provide evidence for a potential beneficial effect of multiple-cat housing for animal shelters.

There are several factors that limit the extent to which our data may be generalized. Importantly, it was impossible to control for highly variable intake characteristics, housing conditions, and experiences of the cats in our study. Cats from the different shelter types (traditional vs enriched) may represent very different populations of cats. Also, to evaluate a broad spectrum of shelter environments, we deliberately chose study sites that differed markedly in their housing options for cats. Furthermore, there were variations in the manner in which cats were housed, even within a particular study site. As a result, the described conditions were generalizations and did not necessarily represent the experience of any particular study cat. It is possible that the variability in experiences of the cats at the different sites had an effect on the stress levels that we were evaluating. However, we examined some of these characteristics, including whether the cat had been a stray, was surrendered prior to entering the study, or had lived outdoors or indoors, and found that they had no effect on either the behavioral scores or the urine cortisol-to-creatinine ratios, indicating that these factors at least were not confounders.

In the study of this report, the behavioral cat stress score did not correlate with the urine cortisol-to-creatinine ratios. We suspect that this method of behavioral assessment systematically underestimated cat stress levels because of the effect of feigned sleep on assigned scores. In use of this behavioral assessment scale, feigned sleep behavior should be taken into account. Physiologic and behavioral assessments of stress in cats may not correlate because they are affected differently by adaptation and coping; how behavioral and physiologic measurements of stress change with time in individual shelter cats remains to be elucidated. Finally, our data indicate that levels of noise and exposure to dogs are potential factors that may contribute directly to stress levels in shelter cats; the influence of noise on stress levels in cats could be investigated by use of more objective methods, such as decibel measures of ambient sound.

The results of the present study are not intended to offer guidance for shelter workers as they assess individual cats under their care. Rather, the goal of our investigation was to collect data to help validate the merits of global changes in shelter design that are being considered and implemented by animal welfare organizations. In our opinion, the most important finding of the present study was that stress levels appeared to be lower among cats housed in enriched environments than among cats housed in traditional shelters. Our results indicate that implementing environmental design strategies based on behavioral theory can make a detectable difference in a measurable parameter of stress among cats in shelters and thus help justify the redesign efforts. Continued improvement in housing and handling conditions for cats in animal shelters is likely to have a major impact on feline welfare.

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Appendix

Behavioral assessment scale used to assign stress scores to 120 cats in 4 animal shelters. Adapted and reproduced with permission from the table "Seven-level cat stress score (a further development of the cat assessment score by McClune 1994.")[16]

Score 1.0—Fully relaxed	Body laid on side or back Belly exposed and slow ventilation Legs fully extended Tail extended or loosely wrapped Head laid on the surface with chin upwards or on the surface Eyes closed or half open and may be blinking slowly Pupils normal Ears half back (normal) Whiskers lateral (normal) No vocalization Sleeping or resting
Score 2.0—Weakly relaxed	Body laid ventrally or half on side, sitting, standing or moving with back horizontal Belly exposed or not exposed and slow or normal ventilation Legs bent, hind legs may be laid out, and legs extended when standing Tail extended or loosely wrapped and tail may also be up or loosely downwards Head laid on the surface or over body and some movement Eyes closed, half opened, or normally opened Pupils normal Ears half back or erected to front Whiskers lateral or forward No vocalization Sleeping, resting, alert or active, and may be playing
Score 3.0—Weakly tense	Body laid ventrally, sitting, standing or moving, and back horizontal Belly not exposed and normal ventilation Legs bent and legs extended when standing Tail on the body or curved backwards, up or tense downwards, and may be twitching Head over the body and some movement Eyes normal opened Pupils normal Ears half back (normal), erected to front, or back and forward on head Whiskers lateral (normal) or forward Meowing or quiet Resting, awake, or actively exploring
Score 4.0—Very tense	Body laid ventrally, rolled or sitting, standing or moving, and body behind lower than in front Belly not exposed and normal ventilation Legs bent, hind legs bent when standing, and extended in front Tail close to the body, tense downwards or curled forward, and may be twitching Head over the body or pressed to body and little or no movement Eyes widely opened or pressed together Pupils normal or partially dilated Ears erected to front or back, or back and forward on head Whiskers lateral or forward Meow, plaintive meow, or quiet Cramped sleeping, resting or alert, may be actively exploring, and trying to escape
Score 5.0—Fearful, stiff	Body laid ventrally, sitting, standing or moving, and body behind lower than in front Belly not exposed and normal or fast ventilation Legs bent or bent near to surface Tail close to the body, curled forward Head on the plane of the body and less or no movement Eyes widely opened Pupils dilated Ears partially flattened Whiskers lateral, forward, or back Plaintive meow or yowling, growling, or quiet Alert and may be actively trying to escape
Score 6.0—Very fearful	Body laid ventrally or crouched directly on top of all paws, may be shaking, and whole body near to ground Belly not exposed and fast ventilation Legs bent or bent near to surface Tail close to the body and curled forward close to the body Head near to surface and motionless Eyes fully opened Pupils fully dilated Ears fully flattened Whiskers back Plaintive meow, yowling, growling, or quiet Motionless alert or actively prowling
Score 7.0—Terrorized	Body crouched directly on all fours and shaking Belly not exposed and fast ventilation Legs bent Tail close to the body Head lower than the body and motionless Eyes fully opened Pupils fully dilated Ears fully flattened back on head Whiskers back Plaintive meow, yowling, growling, or quiet Motionless alert