



Descriptive epidemiology of feline upper respiratory tract disease in an animal shelter

Julie D Dinnage DVM^{1*}, Janet M Scarlett DVM, PhD², James R Richards DVM^{3,a}

¹Director of Animal Protection Medicine, Massachusetts Society for the Prevention of Cruelty to Animals, 350 South Huntington Avenue, Boston, MA 02130, USA

²Cornell University, S1 066 Schurman Hall, Cornell University, Ithaca, NY 14853, USA

³Former Director, Feline Health Center, Cornell University, Ithaca, NY 14853, USA

Upper respiratory tract disease (URTD) is common and spreads quickly in cats residing in animal shelters in the United States. Estimates of the actual incidence of URTD are sparse, yet this information is very important for welfare, economic and research purposes. In a large urban shelter in the northeastern US, 531 individual kittens, 701 litters, and 2203 adult cats were observed for signs of URTD during their stays. The median lengths of stay for adult cats and kittens were 5 and 4 days, respectively. Observations were made over a 50-week period. Approximately 1/3 exhibited signs of infectious respiratory disease. The crude incidence density estimates of URTD were 6.2, 6.7, and 5.6 cases per 100 cats per day among individual kittens, litters and adult cats, respectively. Increasing time of residence in the shelter increased risk of URTD. Using the Kaplan–Meier product limit method, the cumulative probability of developing URTD by day 7 in the shelter was approximately 32% (based on $n = 211$) for litters, 31% ($n = 120$) for individual kittens and 26% ($n = 763$) for adult cats. By day 14, these cumulative probabilities had risen to 84% ($n = 18$), 86% ($n = 7$), and 80% ($n = 51$) among litters, individual kittens and adult cats, respectively. The Kaplan–Meier failure function curve (probability of developing URTD overtime) for adults was significantly lower than those for litters or individual kittens ($P < 0.04$). Among adult cats, those 11 years of age and older had a significantly higher risk of URTD compared to younger adult cats ($P < 0.05$). Male cats (neutered and castrated) had higher URTD rates than ovariectomized females, and purebred cats had a higher risk than those of mixed breeding. In this shelter, cats identified as strays were more likely to exhibit URTD than owner-surrendered cats. Affected cats spent a median of 3 more days than unaffected cats before they developed URTD. Approximately 1/3 (31.4%) of the observed individual kittens and 2/3 (61.8%) of the observed adult cats were euthanased with URTD in this shelter. Other factors such as space and behavior, especially among affected adult cats, were also cited as reasons leading to euthanasia.

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Upper respiratory tract infections (URTD) are found in shelter- and client-owned cats. Unlike in client-owned animals, however, these infections are a major cause of morbidity and mortality in shelters.¹ The stress of being captured or surrendered to a shelter, the concentration of cats and respiratory agents in shelters, variable vaccination histories and immune status, and other factors contribute to high rates of URTD. Kittens, losing their maternal immunity, frequently suffer high mortality following exposure to URTD agents in shelters. Even cats with mild URTD signs risk euthanasia because isolation

cages are limited and infected cats put healthy cats at risk.

In adoption guarantee shelters (often referred to as 'no-kill shelters'), cats with URTD are usually isolated or placed in foster homes and treated before being placed for adoption. These infections cause suffering, consume personnel and financial resources, and limit adoptions. In open admission shelters, where cage space is limited, the protocols for handling cats with URTD vary. Most shelters treat at least some affected cats in isolation rooms or in foster homes. Some do not remove them from healthy individuals, and other shelters euthanase all cats with URTD as soon as they are identified. Even in open admission shelters with isolation, there is often insufficient cage space or time to recover all ill cats, and URTD is a major reason

*Corresponding author. E-mail: jdinnage@mspca.org

^aDeceased.

for choosing animals for euthanasia. Also, cats developing URTD shortly after adoption are a major concern for new owners, veterinarians and shelters seeking to increase adoption rates. Directly or indirectly, URTD is likely to be the leading medical cause of feline death in shelters, and in light of the millions of cats euthanased annually in shelters in the US, URTD is likely to be a leading cause of death of young, otherwise adoptable, cats in this country.

Agents causing feline URTD have been extensively studied. The majority of cases of URTD in cats are caused by two agents, the feline calicivirus (FCV) and the feline herpesvirus-1 (FHV-1), with other agents such as *Bordetella bronchiseptica*, *Chlamydophila felis*, *Mycoplasma* species, and others also causing URTD signs.²⁻⁴ As the signs of URTD (nasal and ocular discharge, and sneezing) are easily recognized by shelter staff, shelter veterinarians, and other shelter personnel, cultures are not usually obtained to identify the causative organism(s). Instead, as control measures are similar for all respiratory agents, affected cats are typically isolated and treated empirically or euthanased. Cultures are usually only evaluated in the face of dramatic increases in the incidence or severity of URTD in a shelter.

Despite its acknowledged frequency in shelters, there are few quantitative estimates of the actual incidence of URTD, its frequency in various subgroups of cats (eg, by gender or age) or the proportion of cats euthanased for URTD in shelters. The objectives of this study were to estimate: (1) the overall incidence; (2) the age-, gender-, breed- and source-specific rates of URTD; (3) the effect of time in residence on risk of URTD; and (4) the proportion of cat's euthanased because of URTD in an animal shelter.

Materials and methods

Study population and environment

Cats in an urban animal shelter in the Northeastern US were observed once daily by a study representative for 50 weeks beginning on July 1, 1999. The open admission shelter in this study impounded approximately 6900 cats with about 36% adopted, 59% euthanased, and 5% transferred, returned to owner, dead on arrival or fostered during the study period. The human population in the community was approximately 152,000. Cats in the holding, isolation and adoption areas were housed in traditional stainless steel cage banks of varying dimensions. The adoption floor also had two communal rooms available that would house up to 10 cats at any given time.

Data collected

Each cat was observed for signs of respiratory disease and other disease signs. The daily observations were recorded on standard forms by two observers during

the study. Also, data regarding age at entry (divided into three age categories for kittens and six age categories for adults: Table 1), gender/neuter status (male intact, male neutered, female intact or female neutered), breed (mixed or purebred), and source (stray or owner-surrender) were recorded. Data relating to each cat's final disposition (eg, adoption, euthanasia) and reason for euthanasia, where appropriate, were similarly abstracted. Cats could have up to three reasons recorded for euthanasia. Information regarding other potential risk factors were also gathered, but are not reported here.

Definitions

URTD was defined by signs commonly used by shelter lay staff to identify cats for isolation or euthanasia. Cats with ocular or nasal discharge, sneezing with or without nasal congestion, coughing, dyspnea, or blepharospasm (in conjunction with other signs) were considered to have an upper respiratory tract infection. Observers identified the nature of discharges as follows: ocular – serous, mucopurulent, brown/crusty or none; nasal – serous, mucopurulent, bloody, or none. Sneezing was either present or not. No cultures were undertaken during the course of the study.

Table 1. Characteristics of cats studied in a shelter in the northeastern United States

Characteristic	Litters (%) <i>n</i> = 701*	Individual kittens (%) <i>n</i> = 531	Cat ≥7 months (%) <i>n</i> = 2203
<i>Age</i>			
0–8 weeks	60	23	
9–15 weeks	26	32	
4–6 months	14	45	
7–11 months			15
1–4 years			71
5–10 years			12
11+ years			2
<i>Gender</i>			
Male intact		28	17
Male neuter		17	19
Female intact		48	47
Female neuter		0	14
Unknown		7	3
<i>Source</i>			
Stray	39	52	35
Owner-surrender	61	47	65
Unknown		1	
<i>Breed</i>			
Mixed	100	98	96
Purebred	0	2	4

*Litters ranged in size from two to six kittens.

If at least one kitten in a litter displayed signs, the litter was considered affected for the calculation of rates. Kittens were defined as those under 7 months of age and adults were those 7 months and older.

Management of URTD in this shelter

Incoming cats were vaccinated for FCV, FHV-1 and panleukopenia within approximately 24–48 h of arrival in the shelter. An intranasal (IN) trivalent vaccine (Heska's trivalent) was the primary vaccine used. However, a parenteral vaccine (Felocel; Pfizer) was administered to a small number of cats whose temperament made it unsafe to administer an IN vaccine or to all cats during brief times when IN vaccine was out of stock. The shelter protocol was to have cats developing signs of URTD moved to the isolation ward if room was available or euthanased, but some were redeemed, adopted, transferred or placed into foster care. The isolation ward had nine cages for the treatment of sick cats, and the policy regarding the management of these cats was variable. Shelter personnel were unaware of the nature of the study and were instructed to continue their usual activities, making decisions regarding euthanasia, treatment, movement to isolation, etc, without regard to the ongoing study.

Data management and analysis

Data were entered, edited and managed in a customized Microsoft ACCESS database. Statistics were estimated using the statistical package, Statistix. Continuous variables were compared between two groups using the Student *t*-test (for Gaussian data) or the Wilcoxon rank sum test (for non-Gaussian data). Comparisons between categorical variables were made using Pearson's χ^2 test of independence.⁵ Statistical significance was defined as $P \leq 0.05$.

Incidence density rates (IDRs)

As cats spent varying amounts of time in the shelter, an overall IDR and characteristic-specific IDRs were calculated. IDRs were estimated by dividing the number of cats developing URTD during specified time periods by the sum of the total cat-days spent in the shelter during the same periods. If a cat with URTD signs was observed by study personnel, that cat was counted as having a URTD event and assigned a cat-day of observation for that day. Cats with URTD on admission were included in the calculations if they were observed. Cat-days are a research measure of cat-time used to estimate the risk of developing disease (or death) in unstable populations where individuals enter and leave frequently.⁶ For example, a cat spending 4 days in the shelter (before adoption, euthanasia, etc) would contribute 4 cat-days of observation to the denominator of an IDR. IDRs for litters were calculated considering the litter as the experimental unit. The cat-days at risk for litters were based on the date of the first kitten in the litter exhibiting

signs (for affected litters) or the total number of cat-days for the last kitten leaving the shelter (for litters with no affected kittens). Comparisons among IDRs were made using the large sample *Z* test suggested by Kleinbaum et al.⁶

Cumulative incidence estimates by day in the shelter were obtained by dividing the number of cats developing URTD on that day by the number of cats in residence through at least that day (that had not yet developed URTD). For example, the cumulative incidence for day 3 in the shelter was estimated by counting the number of cats that developed signs of URTD on their third day in the shelter by the number of cats that were in residence for at least 3 days (minus those cats that developed URTD on days 1 and 2). The estimates were then plotted by time in the shelter to illustrate the trend in risk of developing URTD on particular days of residence in the shelter. The Kaplan–Meier product limit method was used to generate survival/failure curves, demonstrating the cumulative probability of developing URTD overtime in residence in the shelter. Curves were compared using the log-rank test.⁵

Results

Observations were made on 531 individual kittens, 701 litters of kittens, and 2203 cats 7 months of age and older. The remaining ~2100 cats received by this shelter during the study year were not observed by study personnel. Cats who were euthanased shortly after entry (eg, sick on entry, ferals or owner requested euthanasias) were not observed by the researchers and, therefore, were not a part of this study population. In addition, kittens in litters were not counted as individuals in the total study population, but were counted in the total shelter statistics. Finally, the total shelter intake count represented a 52-week period while the study duration was limited to 50 weeks. Less than 9% of all cats entering the shelter were 5 years of age or older. Approximately equal percentages of neutered and intact males, and almost four times more intact than neutered adult females (determined by the presence of an obvious surgical scar) were entered into the study. The majority of cats were owner-surrendered and very few were purebred animals (Table 1).

Twenty-six percent of individual kittens, 32.8% of litters and 30% of adult cats exhibited signs of URTD while in this shelter. The overall crude IDRs were 6.2, 6.7, and 5.6 cases per 100 cats per day among individual kittens, litters and adult cats, respectively, in this population. Although the rates were higher for kittens than adults, they were not significantly different. While the risk of URTD (8.5/100 cat-days) was highest among litters of kittens 4–6 months of age compared to younger litters of kittens, the rates were not significantly different (Table 2). The rates of URTD did not vary significantly among individual kittens 0–8 weeks, 9–15 weeks and 4–6 months of age. Among adults cats, however, those 11 years of

age or older had a significantly higher rate of URTD compared to those in categories <11 years of age ($P < 0.05$) (Table 2).

Neutered adult females had a significantly lower rate of URTD compared to neutered and intact male cats ($P < 0.05$). The rate of URTD among intact female cats was not statistically different from those in the other gender/neuter groups. Similarly, purebred and stray adult cats were at significantly higher risk of URTD compared to adult mixed-breed cats ($P < 0.001$) and owner-surrendered cats ($P < 0.01$), respectively. There were no differences in risk of URTD between stray and owner-surrendered cats or litters (Table 2).

As the incidence of URTD within age groups was examined, the importance of time spent in the shelter became clear. Regardless of age group (individual kittens, litters of kittens, adults), the probability of developing URTD rose steadily with increasing time spent in the shelter among individual kittens, litters and adult cats (Fig 1). Estimated using the Kaplan–Meier failure curve in Fig 1, the cumulative probability of developing URTD by day 7 in the shelter was approximately 32% (based on $n = 211$) for litters, 31%

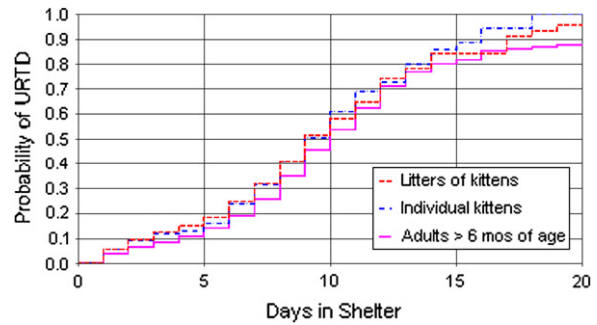


Fig 1. Kaplan–Meier failure curve showing the cumulative probability of URTD in cats by time and age group in a Northeastern shelter.

($n = 120$) for individual kittens and 26% ($n = 763$) for adult cats. By day 14, these cumulative probabilities had risen to 84% ($n = 18$), 86% ($n = 7$), and 80% ($n = 51$) among litters, individual kittens and adult cats, respectively. Figure 1 is interpreted as follows: if 100 adult cats were observed in this shelter for 2 weeks, 26% would be expected to develop URTD by day 7 and 80% (of the 100) would develop URTD by day 14. In Fig 1, the Kaplan–Meier failure function curve (probability of developing URTD overtime) for adults was significantly lower than those for litters or individual kittens ($P < 0.04$).

The probability of exhibiting signs of URTD on individual days in residence remained low (<6% for all groups) until day 6, when it began to increase steadily. Cumulative incidence estimates are shown through day 12. As the number of cats still in residence in this shelter and the precision of cumulative incidence estimates declined sharply after day 12, one incidence estimate is presented for days 13 and beyond (Fig 2). This figure shows the probability of cats in this shelter developing URTD on particular days in the shelter, given that they had not already done so.

The median length of stay in the shelter was 5 days for all cats (range: 1–57 days). The median length of stay for adults and individual kittens were 5 and 4 days, respectively. Kittens, litters and adult cats

Table 2. Age-, gender/neuter-, breed- and source-specific IDRs (per 100 cat-days) of URTD in a shelter in the Northeastern United States

Characteristic	Adults	Individual kittens	Litters of kittens*
<i>Age</i>			
0–8 weeks	–	5.3	6.4
9–15 weeks	–	6.5	6.3
4–6 moths	–	6.3	8.5
7–11 months	4.9 ^a	–	–
1–4 years	5.8 ^b	–	–
5–10 years	4.8 ^c	–	–
≥11 years	11.5 ^{a,b,c}	–	–
<i>Gender</i>			
Male intact	6.4 ^a	6.0	–
Male castrate	5.9 ^b	5.0	–
Female intact	5.5	6.3	–
Female spay	4.4 ^{a,b}	–	–
<i>Breed</i>			
Mixed	5.5 ^a	–	–
Purebred	8.5 ^a	–	–
<i>Source</i>			
Stray	6.2 ^a	6.4	5.9
Owner-surrender	5.3 ^a	6.0	7.0

*A litter was considered affected if at least one kitten displayed URTD signs. ^{a,b,c}Rows within a variable that share a letter were statistically different ($P \leq 0.05$).

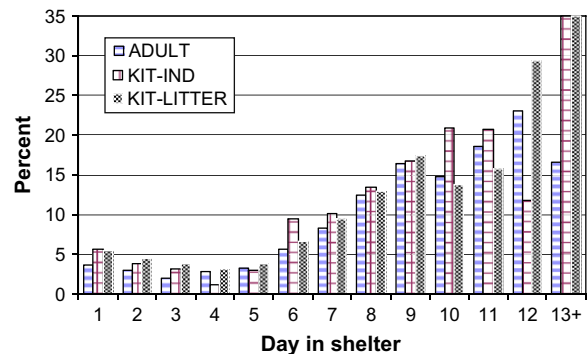


Fig 2. Daily incidence of URTD by age group and day in a Northeastern shelter.

developing URTD spent a significantly higher median number of days in the shelter before development of URTD, compared to those not showing signs in each age group ($P \leq 0.05$) (Table 3). Overall, including treatment time, adults and individual kittens with URTD spent a median of 10 total days (range: 1–53) and 9 days (range: 1–43) respectively, in the shelter before leaving or being euthanased. The differences in risk among cats by age group, surrender or gender/neuter status were not explained by length of residence alone (data not shown). Additional analyses are planned to evaluate multiple risk factors simultaneously.

Dispositions

Not surprisingly, the final disposition of cats in this shelter varied by age and the presence of URTD. Adults (without regard to disease status) were significantly more likely to be euthanased than individual kittens ($P = 0.002$), and conversely, individual kittens were significantly more likely to be adopted than adult cats ($P < 0.001$). Kittens with URTD were twice as likely to be euthanased compared to kittens with no signs ($P < 0.001$), but, interestingly, in this shelter the proportion of adults euthanased did not vary significantly by whether or not they displayed signs of URTD (Table 4).

In this shelter, URTD was the most common reason cited for euthanasia of kittens and of similar frequency to behavioral concerns, poor health and space in adult cats. As more than one reason could be cited for euthanasia, cats with URTD may well have also been euthanased for poor health or other reasons (Table 5).

Isolation

A total of 252 cats and litters were treated in this ward during the 50 weeks of observation. Of these, 21 had missing information regarding sex or age and were

Table 3. Days of residence in shelter before development of URTD (or exit if no URTD) by age and URTD status

	Median	1st and 3rd quartiles	Range
<i>Litters</i>			
URTD	6 ^a	2, 9	1–19
No URTD	3 ^a	2, 6	1–27
<i>Individual kittens</i>			
URTD	6 ^a	2, 8	1–18
No URTD	3 ^a	2, 5	1–15
<i>Adult cats</i>			
URTD	7 ^a	3, 9	1–33
No URTD	4 ^a	2, 7	1–57

^aRows within age groups the same letter were significantly different ($P \leq 0.05$).

Table 4. Disposition of all cats and cats placed in isolation by age group and respiratory disease status (as defined by study personnel) during a 50-week period in a shelter in Northeastern United States

Dispositions*	All cats (%)		Cats in isolation (%)	
	Individual kittens	Adults	Individual kittens	Adults
<i>Overall</i>	(<i>n</i> = 528)	(<i>n</i> = 2199)	(<i>n</i> = 35)	(<i>n</i> = 145)
Adopted	58.5	33.0	40.0	23.8
Euthanased	31.4	61.8	45.7	57.2
Other	10.0	5.2	14.3	9.0
<i>URTD</i>	(<i>n</i> = 137)	(<i>n</i> = 659)	(<i>n</i> = 30)	(<i>n</i> = 109)
Adopted	42.3	31.0	46.7	39.4
Euthanased	49.6	63.7	40.0	48.6
Other	8.0	5.3	13.3	11.9
<i>No URTD</i>	(<i>n</i> = 391)	(<i>n</i> = 1540)	(<i>n</i> = 5)	(<i>n</i> = 36)
Adopted	64.2	33.8	0	16.7
Euthanased	25.1	61.0	80.0	83.3
Other	10.7	5.2	20.0	—

*Some cats were missing disposition data.

omitted from further analyses. Of the remaining 231 cats or litters, 41 (17.7%) were litters, 38 (16.5%) were individual kittens, 22 (9.5%) were queens (with litters), and 130 (56.3%) were other adult cats. Overall,

Table 5. Frequency of reasons for euthanasia and other dispositions among kittens and adult cats in an animal shelter in the Northeastern United States (as determined by shelter staff)

Disposition*	Individual kittens <i>n</i> = 528		Adults ≥ 7 months <i>n</i> = 2199	
	Number	%	Number	%
Euthanasia†	165	31.4	1359	61.8
Age	7	1.3	54	2.5
Poor health	52	9.9	428	19.4
URTD	86	16.3	469	21.3
Behavior	40	7.5	576	26.2
Owner request	0	—	4	0.2
No room	54	10.2	395	18.0
Dead on arrival	0	—	0	—
Transferred	5	1.0	21	1.0
Adopted	309	58.5	723	32.9
Returned to owner	26	4.9	68	3.1
Reclaimed/released	3	0.6	0	—
Fostered	23	4.4	28	1.3

*Three kittens and two adults had missing dispositions.

†Cats could have up to three reasons for euthanasia, so numbers do not add to total euthanasias.

178 (77.1%) of the 231 cats or litters in isolation had URTD signs during the study. Excluding litters, 84.2% (32/38) and 76.3% (116/152) of individual kittens and of adult cats, respectively, had URTD signs. In this shelter, approximately 22% (30/137) of the individual kittens and 17% (109/659) of the adult cats with URTD were placed in isolation for treatment. In isolation, a significantly higher proportion of adult cats with URTD (39.4%) was adopted than adult cats with other illnesses (16.7%), and conversely, a significantly lower percentage of adult cats with URTD was euthanased than cats with other conditions ($P < 0.05$) (Table 4). Similarly, among kittens, a higher percentage with URTD was adopted (and a lower percentage was euthanased) than those with other conditions, but the differences were not statistically significant. Among all cats with URTD, the distribution of dispositions between adult cats and kittens did not differ significantly (Table 4).

Adult cats with URTD spent a significantly higher number of median days in isolation (6) than adults with other conditions (2) ($P < 0.0001$). Kittens with URTD spent a median of 9 days compared to a median of 2 days for kittens with other conditions ($P = 0.06$).

Discussion

Estimates obtained in this study provide quantitative approximations of how commonly upper respiratory infections occur in various subgroups of cats in shelters, augmenting qualitative words like 'very commonly or frequently'. They must be viewed cautiously, however, as they are based on one shelter only and differences in URTD occurrence among shelters is undoubtedly affected by many factors including crowding, housing, length of residence, timing of vaccination, sanitation measures, population demographics, differences in other protocols, and potentially the strains and distribution of URTD pathogens. The rates and the risk factors reported here reflect factors associated with showing signs of URTD at any time during cats' residence in the shelter. These data must be viewed as reflecting the risk of acquiring URTD before and during residence in this shelter. Also, the risk factors reported were not adjusted for other possible confounding factors (including length of residence) and must be viewed keeping that in mind. Additional analyses are planned to evaluate risk factors associated with incubating disease at entrance and with disease acquired while in residence, as well as controlling for possible confounding variables.

General recognition of importance of URTD in shelters

In the authors' experience, upper respiratory infections in shelters are the most common cause of illness in cats, and as a consequence, the most common health-associated cause of euthanasia in open

admission shelters and of treatment in all shelters. FHV-1 (feline viral rhinotracheitis (FVR)) and FCV are the most common causes of URTD in cats. Much of the literature suggests that these agents contribute about equally to the occurrence of URTD and account for approximately 80–90% of all cases of feline URTD.^{2–4,7} Other agents contributing to URTD in shelters include *Bordetella bronchiseptica*, *Mycoplasma* species and *Chlamydomphila felis* (formerly *Chlamydia psittacae*).^{4,8} Most studies of URTD frequency are based on detection of virus shedding at one point in time (prevalence studies), and most have been conducted in privately owned cats. Studies of the incidence of infection and of clinical disease are needed to accurately assess risk to cats of developing these infections in shelters, particularly in light of the differences in latency and duration of shedding among the various respiratory agents.

In the shelter studied, approximately 1/3 cats displayed signs of URTD before being euthanased or leaving the facility. Both length of residence in the shelter and age of cats were strongly associated with risk of URTD. Cats 11 years or older had the highest rate of URTD of cats in this shelter (Table 2), possibly reflecting the high proportion of cats in this age group that are latently infected with herpesvirus, cats entering the shelter already infected, high stress levels, or advanced age. Similarly, kittens (individual and in litters) had higher rates of URTD than adult cats. This higher risk among kittens is consistent with the literature relating to non-shelter populations.^{3,9} Unfortunately, recording of placement in foster care was inconsistent in the shelter records, precluding further examination of its impact. In light of the higher risk to kittens, many shelters have active foster care programs to reduce their exposure in the shelter. Once in foster care, shelters often ask foster care providers to take kittens directly to off-site adoption sites to avoid exposing them to the shelter environment. In shelters where these young animals must return to the shelter, they should ideally be housed apart from kittens and cats already residing in the shelter.

The data regarding litters must be viewed cautiously. Attempts were made to track individual members of litters with the shelter records, but missing data made this impossible. As members of most litters in this shelter were housed together, if one kitten became affected, the litter was considered affected, although not all members may have developed URTD. The litter-related data were included to assess whether the occurrence and onset of URTD in at least one litter member differed from that of individual kittens and adults. The rates among litters of kittens were not statistically different from those for individual kittens.

Although time spent in the shelter was anticipated to influence URTD risk, the magnitude of its effect was surprising. The cumulative probability of developing URTD escalated quickly with increasing time spent in the shelter, progressing from approximately

5% after the first 2 days, to 21% after 1 week, to over 80% after 2 weeks in the shelter for cats of all ages combined. (It should be noted that as the length of time in residence in the shelter increased, the number of cats remaining in the shelter declined, and, therefore, the cumulative probability and cumulative incidence estimates in Figs 1 and 2 became increasingly imprecise.)

The observation of increasing risk of URTD with time spent in residence in this shelter is in contrast to that observed in a study of five rescue animal shelters in the United Kingdom.¹⁰ This difference is intriguing and may reflect differences in facilities, type and density of housing, quarantine and isolation protocols or other factors. In the largest center studied in the UK, for example, the shelter had a purpose-built quarantine unit with a separate isolation unit and unique staffing. Clarification of the factors associated with this difference in URTD risk may be important to achieving lower URTD rates in the US.

When age and time in the shelter were considered, adult cats had a significantly lower probability of developing URTD throughout their first 2 weeks of residence in the shelter compared to kittens (Fig 1). The daily incidence of URTD remained low until the sixth day of residence in the shelter and then rose until at least day 12 (Fig 2), emphasizing the need to minimize time cats spend in the shelter. URTD manifestations in the first 3–4 days in the shelter predominantly reflect infections acquired before entering the shelter and those identified after 5 days or more are likely to have been acquired as a result of exposure in the shelter (given the incubation period of the feline respiratory agents is approximately 1–6 days).

Information regarding the frequency of feline URTD in shelters is sparse, but two studies provide insight into the incidence of these infections in other shelters in the US. In their clinical trial of vaccine efficacy in a California shelter among 57 cats (only nine of whom developed URTD in the shelter), Edinboro et al¹¹ estimated a 5% increase in risk for each day in the shelter (adjusting for age, breed, source, and vaccination status). Using this estimate, cats in that shelter had an estimated cumulative probability of developing URTD after 7 days in the shelter of approximately 35%, compared to our estimate of ~30% for the same time period (Fig 2). In another shelter study in California, Pedersen et al¹² demonstrated that the prevalence of herpesvirus shedding was low (~4%) at entry into shelters, but increased more than 10-fold (to 51.7%) following 1 week's residence (either through recrudescence of latent infections or acquisition of infection). In contrast, the prevalence of FCV shedding at entry was higher (11%) than that of herpesvirus, but did not increase nearly as rapidly, slightly exceeding 16% after 1 week. The number of samples studied declined dramatically by the second week, but among the remaining cats, 40% (2/5) of cats were still shedding FHV-1 at 2 weeks, and 20% (1/5) were shedding calicivirus.

Although these researchers did not record signs in the animals studied, their data and the biology of herpesvirus-1 suggest that the rising incidence of URTD in shelters reflects predominantly herpesvirus infections in the first week and probably during the second week as well. These infections are a consequence of new exposure and the recrudescence of latent infections in stressed cats. Regardless of the cause, transmission (or recrudescence) of respiratory agents is rapid and efficient in shelter environments, resulting in high rates of URTD within 1–2 weeks.

As length of residence in a shelter is strongly related to risk of developing URTD, quarantine measures for URTD in most US shelters probably increase the incidence of URTD in the shelter, rather than reduce it. The usual preventive medicine recommendation of quarantining is based on the premise that newly introduced animals incubating disease at the time of entry will develop signs during quarantine before exposing healthy members of the population. This recommendation assumes that quarantine space is adequate for the number of animals entering the population, that most animals entering the facility are not carrying a latent agent activated by stress, that cats in quarantine are truly isolated from each other, and that fomite transmission is minimized. In the authors' experience, most shelters often face an incoming population in excess of the amount of available housing, the quarantine facilities, when available, are often inadequate, and a high proportion of incoming cats is likely to be latently infected with herpesvirus. The herpesvirus is highly infectious, circulating widely in the cat population, and following initial infection, 80–100% of cats become latently infected.¹³ Approximately 45% of these cats will begin re-shedding virus 4–11 days following a stressful event such as entering a shelter.¹⁴ Kittens may become infected following exposure to an infected queen, even in the presence of maternal antibodies.¹³ For these reasons, quarantine to minimize URTD seems ill-advised for cats in most US shelters.

For those shelters that can hold cats for 7–10 days (eg, sanctuaries), quarantine may reduce overall URTD rates, but this suggestion requires further study. An added benefit to minimizing time spent by each cat in the shelter is to free-up cage space for additional cats, thus maximizing the number of cats that shelters can place for adoption in any given time period.¹⁵

Failure to quarantine may result in the periodic introduction of other infectious diseases (eg, feline panleukopenia), but constant vigilance for any signs of disease in sheltered cats is essential, whether or not quarantine is used. Cats with signs of infectious disease must be promptly identified and isolated from healthy cats. Minimizing residence in the shelter may also result in more respiratory disease following adoption. Edinboro et al¹¹ reported that approximately 36% of cats receiving subcutaneous FVRCP alone and 19% of cats receiving a combination of

subcutaneous and IN herpesvirus/calicivirus vaccine developed URTD after adoption. As upper respiratory tract infections are generally mild and self-limiting especially outside of the stressful shelter environment, the authors have observed that many shelters choose to alert prospective adopters to the risk of URTD following adoption. As the risk of severe clinical disease is higher among kittens than adult animals, well-managed foster programs for the youngsters are also an important adjunct to a successful URTD shelter control program.

Other possible risk factors

Among adult cats, males (neutered and intact) had the highest rates of URTD, both of which were significantly higher than the rate for spayed females. The rate of URTD among intact female cats was not statistically different from those in the other gender/neuter groups (Table 2). Intact male cats are often more likely to be outdoor cats compared to spayed females, and this difference in rates may reflect differences in exposure before entering the shelter. The reason(s) for the difference in rates between the neutered males and females is unclear. One previous study in shelter cats failed to find a gender/neuter difference in risk of URTD,⁸ while another in privately owned cats found intact male cats to have a higher risk for FHV-1 isolation.⁹

Stray cats were more likely to exhibit signs in the shelter than those surrendered by their owners. Edinboro et al¹¹ also reported an elevated risk among stray cats (vs owned), in a California shelter with a relative risk of 6.4, although with their limited sample size, the difference was not statistically significant. Stray cats may be more likely to enter the shelter already infected or unvaccinated, have greater susceptibility to infection due to poor nutrition or concurrent illness, or have longer residence in the shelter due to mandatory holding periods for unowned animals. Although this shelter was not subjected to any mandatory holding periods for stray cats, the general policy was to hold stray cats a minimum of 48 h unless a decision to euthanase for medical reasons was made. Other factors such as stress also probably play a role in determining URTD risk. In 2007, Dybdall et al¹⁶ reported data suggesting that owner-surrendered cats were more stressed than stray cats during the first 3 days in a shelter. If stress during the first 3 days in a shelter increases risk of URTD, these data would be consistent with owner-surrendered cats having a higher risk of URTD than stray cats. This is directly in contrast to what was found in this study. Additional research is needed to clarify the relationship of status at surrender (owner-surrender versus stray) with stress and risk of URTD, taking into account the timing of the development of signs and other potential confounding factors.

Purebred cats were also more likely to exhibit URTD (RR = 8.5) while in the shelter compared to cats of mixed breeding, a finding also reported by Edinboro et al¹¹ for purebred cats or purebred crosses.

These often pampered cats may experience higher stress levels in the shelter or there may be genetic influences not yet well understood. This association requires further study. Other studies of source, gender/neuter and purebred status and the risk of URTD in shelters have focused on individual causative organisms (eg, *Bordetella* or *Chlamydophila* species) and are not directly comparable to this study.^{17,18}

Impact of URTD on shelters

Among kittens, those developing URTD were approximately twice as likely to be euthanased compared to their healthy counterparts in this shelter (Table 4). Conversely, affected kittens were less likely to be adopted. Their deaths serve as a reminder of how important it is to identify effective strategies to reduce the influx of cats into our animal shelters and reduce the incidence of URTD. The effect of URTD on likelihood of euthanasia is more complicated for adult cats. The data suggest that URTD, space pressures, behavioral concerns, and other health issues all contributed significantly to decisions to euthanase adult cats who were more numerous in this shelter population and who were generally less adoptable than kittens.

Once signs are evident, some shelters euthanase cats with URTD immediately. Many shelters, like this one, isolate at least some of the affected cats, however. In this shelter, approximately 22% of the individual kittens and 17% of the adults cats with URTD were placed in isolation for treatment. Others may have been missed or left in the general population, contributing to the rates of URTD in this shelter. Similarly, some cats receiving IN vaccination may have developed vaccine-induced signs. These cats, appearing to have signs of URTD, may have also increased the observed cases of URTD in this shelter. Despite treatment, approximately 40% of the kittens and 50% of the adults cats were ultimately euthanased either because of the severity of their disease or space pressures on the isolation ward. Shelters have differing policies regarding the management of cats with URTD in isolation. Some allocate a fixed time frame within which cats must recover or be euthanased; other shelters treat them until they recover (unless they become morbidly ill); and still others, allow variable time in isolation, depending on factors such as pressure for cage space or response to treatment, as was true in this shelter.

Among cats with URTD, the median length of stay for kittens and adult cats before development of URTD were 6 and 7 days, respectively, in this shelter (Table 3). Overall, cats developing URTD spent a median of 9–10 days in the shelter. As many of these cats developing URTD were euthanased, the length of time added to the residence of cats with URTD not euthanased was undoubtedly longer. The costs for treatment and staff time have not been quantified, but are likely to be significant in the resource-poor environment of this and other shelters.

Limitations

The incidence estimates of URTD in this study are undoubtedly low. Cats whose signs were identified before the study observer could record them or who had signs at admission, may have been euthanased before being recorded introducing bias in to the estimates. Similarly, cats euthanased for space or reasons other than URTD, may well have developed signs had they remained in the shelter.

The study is also limited by observing disease only in the shelter (as described previously). Cats acquiring URTD while in the shelter, but developing signs following adoption or reclamation by their owner are not represented in the rates reported. Therefore, the reported rates should be regarded as minimal estimates. Also, as culturing of affected cats was not part of the study protocol, the agents causing disease in this shelter were unknown. It is possible that the distribution of disease across various subgroups of cats (eg, by gender, source) may vary by the specific agent causing their signs. By studying all cats affected with URTD without regard to the causative agent(s), the rates we observed may be peculiar to this shelter and only to others with a similar distribution of agents.

Summary

Data from this study provide quantitative estimates of the frequency of URTD developing in cats in an animal shelter during a 50-week observation period and document the strong association between length of residence in a shelter and the rising risk of developing URTD among cats of all ages. There have been numerous papers written about the control of URTD in cats.^{3,4,19} The biology and epidemiology of feline respiratory agents make them difficult to control in the shelter environment. Results from this study suggest that shelters must focus efforts on continuing to minimize the length of time cats spend in the shelter by increasing adoptions, redemptions, and expanding foster care programs that achieve this goal. Similarly, as the herpesvirus appears to play such an important role in the genesis of respiratory infections in shelters, attention to minimizing stress in shelter cats is essential. While more studies are needed, preliminary results also suggest that attention should be paid to special management of kittens, and purebred and stray adult cats to reduce their likelihood of developing and spreading URTD. Of course, shelters should be encouraged to develop programs that prevent cats from ever entering shelters so that they are not exposed to this high risk environment.

The frequency of URTDs, their association with euthanasia (particularly among kittens) and their association with increased length of residence (and presumably cost to the shelter) threatens the welfare of all sheltered cats and depletes scarce shelter

resources. Additional studies are needed to better understand the complex inter-relationships among these agents, their feline hosts, the shelter environment and management protocols. With better information, veterinarians and shelter personnel can reduce the incidence of URTD and its many negative impacts on the welfare of shelter cats. Publication of these data will hopefully stimulate shelters to begin to quantify and summarize their own data. The ultimate goal is to better understand the occurrence of disease in order to identify strategies to best control these infections.

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