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Pets in Lower Socioeconomic Communities Have a Higher Exposure to Second-Hand Smoke

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Abstract

Introduction: Second-hand smoke (SHS) represents a significant public health issue. Lower socioeconomic status has been associated with a higher baseline rate of smoking. The hypothesis was that animals living in lower socioeconomic areas are more likely to be exposed to SHS.
***Methods*:** Urine samples submitted for routine testing from pets living low-, lower-middle-, upper-middle-, and high-income areas based upon ZIP code were collected from a reference laboratory, and the presence or absence of urinary cotinine, as a marker of smoke exposure, was determined using a point of care assay. Results were compared using logistic regression.
***Results*:** A total of 168 samples were evaluated. Animals living in the lowest socioeconomic Postal (ZIP) codes had a higher rate (26.7%) of positive urine cotinine compared to animals living in a higher income Postal (ZIP) code (4%).
***Conclusion*:** The rate of exposure to SHS, as supported by urine cotinine levels, is much higher in animals in low socioeconomic areas. Consideration should be given to promoting smoking cessation and providing resources to encourage quitting.

Keywords: *cotinine*; *second-hand smoke*; *environmental risk*; *education*; *poverty*

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Second-hand smoke (SHS) exposure is linked to a variety of health issues in people including respiratory issues and increased risk of cardiac disease and cancer among others.[1,2] SHS is defined as exposure to smoke by being in the vicinity of a smoker, most commonly of cigarette smoke.[1–3] It is well-recognized that people from lower socioeconomic status (SES) have a higher rate of smoking; rationale for this likely multifactorial, but includes social influences such as more smoking relatives and friends, ease of access, a lack of negative feedback from the community and excessive targeting by Big Tobacco as well as a lack of exposure and support for cessation programs.[4,5] Third-hand smoke is the residual residue/odor of smoke left in the environment even after the smoker is not in the room. Some pets arrive at the veterinary clinic with a smell of smoke either on their fur or on blankets/pet carrier. SHS smoke exposure in children is associated with an increased risk of dental caries, respiratory infection, asthma and possibly neuro-developmental diseases.[6–9] Prior investigations exploring pet exposure to SHS have involved questionnaires (e.g. asking about the number of smokers in house, packs/day; time spent indoors), and evaluation of urine or serum cotinine as evaluated by mass spectrometry or enzyme-linked immunosorbent assay (ELISA).[8–17]

Documentation of exposure to SHS in pets can have important implications for human and animal health, as this can prompt a discussion surrounding the recommendations to quit smoking as well as the opportunity to provide resources to the clients to help accomplish this goal. The goal of this study is to determine if companion animals living in lower socioeconomic homes are more likely to have exposure to SHS, as assessed by a point of care urinary cotinine test, than those pets that live in higher socioeconomic households. Exposure to SHS may be associated with increased health risk in dogs including nasal cancers and respiratory signs. In addition, discussion about potential risks for smoking in people and SHS exposure in pets and other family members may be helpful in getting owners to stop smoking, ideally overall, but at least around children and pets.[18–20]

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Methods

The protocol for this study was approved by the Tufts Cummings School of Veterinary Medicine Clinical Studies Review Committee at Tufts University, North Grafton, MA. Informed consent was waived by the committee. Leftover urine samples submitted from routine testing were collected from three laboratories. Samples from animals living in Worcester (two ZIP codes: 01608 and 01610), Webster/West Brookfield, Westboro/Walpole, or Wellesley/Weston were eligible for inclusion. The ZIP codes were of the owner's home address. No further information was collected about the client. The ZIP code was obtained from the medical record case number. The samples represented low-, lower middle-, upper middle- and high-income areas or SES, respectively. The median yearly incomes for these areas in 2024 were $31,000, $59,000, $132,000 and $250,000, respectively (U.S. Census Bureau). The low SES income samples all came from our affiliated income-screened clinic, where all clients are required to receive government assistance in the form of supplemental nutrition assistance program (SNAP), special supplemental nutrition program for women, infants, and children (WIC) or residing in the local housing authority. The lower middle, upper middle- and high-income samples were collected from animals attending the other teaching/referral hospitals (Cummings School of Veterinary Medicine, Grafton, MA and TVETS, Walpole MA). Urine samples were transferred to cryotubes, labeled as species and with the subject's ID number and corresponding town. The tubes were stored in a standard freezer at -80 °C until laboratory analysis. No further identifying information was recorded.

Sample preparation and analysis

Frozen urine samples were thawed to room temperature and mixed to suspend any settled precipitate. All samples were analyzed using NicoTests™ Cotinine (COT) Extra Sensitive Urine Test Device Rapid Test Panel.[a] The NicoTest is a rapid, one-step test for qualitative detection of cotinine in urine. The test device is a lateral flow chromatographic immunoassay and detects cotinine in urine at cut-off concentrations of 5 ng/mL; this cutoff concentration is expected to be positive for up to 3 days post-nicotine exposure. The test panel utilizes a monoclonal antibody to detect elevated levels of cotinine in urine; the tests yield positive when the cotinine in urine exceeds 5 ng/mL. The NICO test was validated by comparing with sample analyzed by mass spectrometry in people, although it was not directly compared in animals (personal communication). It is assumed that dogs and cats metabolize cotinine similar to humans.[16] Data in research rabbits document urine cotinine levels consistent with human exposure when nicotine patches are used.[17] Urine samples were tested for cotinine and classified as positive or negative.

A logistic regression analysis was performed to evaluate the association between town income level and urinary cotinine status, defined a positive or negative test for urine cotinine. Cotinine status was treated as a binary outcome variable (positive cotinine vs. negative cotinine). Town income level was categorized as low income, middle income, and combined middle-high/high income, with low-income towns serving as the reference group. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to estimate the association between town income level and the odds of a positive cotinine level. Statistical significance was defined as a two-sided P-value < 0.05. All analyses were performed using logistic regression modeling, comparing the number of positive versus negative urine cotinine results across income levels.

Results

A total of 168 urine samples from dogs, cats and one rabbit were available for analysis. Table 1 shows the characteristics of the animals enrolled, including total number of each species collected per income category. Of the 168 animals enrolled, 17 (10%) tested positive for urine cotinine. Table 2 displays the urine samples testing positive for cotinine as a marker of environmental tobacco smoke (ETS) exposure rate by species and SES. Worcester animals had a 27% rate of ETS exposure, Webster/West Brookfield had an exposure rate of 12%, while an exposure rate of 1% was observed in Westboro/Walpole and Wellesley/Weston had a 0% ETS exposure rate. Residence in middle-high (Westboro/Walpole) or high-income towns (Wellesley/Weston) was associated with significantly lower odds of a positive cotinine level compared with the low-income town (Worcester) (OR: 0.03, 95% CI: 0.004–0.23, $P < 0.001$). Residence in middle-low income towns (Webster/West Brookfield) was associated with lower odds of a positive cotinine level; however, this association did not reach statistical significance (OR: 0.36, 95% CI: 0.11–1.25, $P = 0.11$).

Discussion

This study provided preliminary evidence supporting that SES is associated with exposure to SHS in pets, similar to what is seen in children in lower income homes.[5] The overall percentage of positive test results for exposure to SHS was 10%, which is similar to the state average for humans.[b] However, the difference between affluent suburbs and the low-income city was marked at 26.7% exposure rate in animals with a low SES compared to 1% in combined high and middle high-income setting. The knowledge of this discrepancy represents

a. NicoTests™ Cotinine (COT) Extra Sensitive Urine Test Device Rapid Test Panel Lot Number COT16060003 ed. Albany, NY2017

b. https://www.lung.org/research/trends-in-lung-disease/tobacco-trends-brief/rates-by-state

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Table 1. Species and socioeconomic location of urine samples tested

	Total *N* =	Canine *N* =	Feline *N* =	Rabbit *N* =
Worcester (low-income)	45	30	15	0
Webster/ West Brookfield (lower-middle)	33	28	5	0
Walpole/Westboro (upper-middle)	76	49	26	1
Wellesley/Weston (high-income)	14	5	9	0
Total	168	112	55	1

Table 2. Urine samples with positive results including species and socioeconomic location

N = 168	All positives *N* =	ETS exposure rate (%)	Canine positive *N* =	Canine ETS exposure rate (%)	Feline positive *N* =	Feline ETS exposure rate (%)
Worcester (low-income)	12	26.7	6	25	6	66.7
Webster/West Brookfield (lower-middle)	4	12.1	4	16.7	0	0
Walpole/Westboro (upper-middle)	1	1.3	1	2.0	0	0
Wellesley/Weston (high-income)	0	0	0	0	0	0
Total	17	10.1				

a novel target for controlling or eliminating exposure to SHS in pets and people by extending the conversation about pet's health during community health visits or simply by displaying posters with information about risks of smoking as well as opportunities to promote smoking cessation.

Exposure to SHS is a serious public health problem.[19,20] Humans are often involuntarily exposed to SHS and subsequently at risk for diseases triggered by tobacco exposure including increased risk of respiratory disease, some cancers, cardiovascular disease and diabetes. One study showed a higher risk of nasal cancers in long-nosed dogs exposed to SHS.[8] One similar study in dogs exposed to cigarette smoke was unable to show an increased risk of lung tumors but was considered underpowered.[9] Similarly, there was no clear association between chronic cough and SHS exposure in dogs.[10] Poor indoor airway quality, including the presence of tobacco smoke has been linked to respiratory disease in cats in Taiwan.[11] Another study in cats documented an increased rate of oral squamous cell carcinoma in cats with exposure to environmental tobacco smoke.[12]

One vital aspect of community medicine is improving the health of all family members, not just the patient (pet) that is being treated. Knowledge that a beloved pet could be affected can help to promote smoking cessation, with one study supporting up to 50% of pet owners would try to decrease or eliminate their pet's exposure to SHS if they knew the risks.[14] On-going studies should continue to address the risk of SHS to pets, including respiratory diseases, cardiac disease and cancer.

High smoking rates are linked to early death in people.[21] The actual risks of SHS exposure in animals remain to be elucidated although accumulating evidence supports the risks to animals.[11,12,15]

One benefit of detecting SHS exposure in pets is the potential positive effect on human health, particularly in children, who may suffer a lifetime of consequences from exposure, including health and education disparities. Animals may not experience all the side effects of SHS due to shorter life spans as some of the influence in people is due to prolonged exposure. However, children, including preschoolers are affected, which suggests that years are not required for at least respiratory signs.[19,20,22] In dogs and cats, differences in diagnostics may also preclude understanding if a cough is due to SHS or chronic bronchitis or a combination. In children with any respiratory signs, family members are instructed to stop smoking, although it is similarly unclear at times if the respiratory signs are due to SHS versus intrinsic asthma.[18] Daniel and colleagues identified increasing opportunities to help with smoking cessation by screening children for SHS exposure.[18] These opportunities including improved screening of children, and when a positive test result was found, providing non-judgmental literature and entry into smoking cessation programs. This suggests that the community veterinary medical clinics could similarly provide literature and recommendations for how to stop or decrease smoking.

Towns included in this study were selected from those beginning with the letter 'W' for convenience, as both the low-income clinic and affiliated referral hospitals are

located in such areas. While Massachusetts is generally an affluent state, these towns span a range of socioeconomic contexts, including both lower- and higher-income communities.

Documentation of exposure to SHS can be made by questioning the client, although owners may be inclined to downplay or deny the exposure to cigarette smoke. Quantitative methods have evolved to determine evidence of metabolism of nicotine, including the assessment of urine cotinine, which is the stable end-product of nicotine metabolism.[23] The NicoTest assay provides point of care testing with positive or negative results for cotinine. Cotinine levels can be more quantitatively assessed exposure utilizing gas chromatography and mass spectrometry (GC/MS) if specific information is required.[15,16] Cotinine levels have been previously evaluated in dogs although the NicoTEST was not used. Cotinine levels fall after exposure stops, and so if a pet or a smoker is absent from the home, levels will not reflect actual exposure. The NicoTest assay used in this study has been validated in humans, not in animals. It is possible that performance could be different in different species.[23] Additionally, if urine is very dilute or concentrated, this could impact the concentration, so some clinicians recommend normalizing for a urine specific gravity. The urine specific gravity was not recorded in the animals in this study, but this variable should be considered in future studies.

Limitations

This study only evaluated a few specific locations in the state of Massachusetts, which already has lower baseline rate of smokers with 10.4% smokers compared with states such as West Virginia with a 21%.[b] As the study was blinded, the degree, if any, of respiratory signs or other conditions in pets was unknown. Furthermore, urine assays have the disadvantage of being subject to dilution and collection time due to the half-life. The accepted estimated half-life of cotinine averages 16 to 18 h, therefore, spot urine sampling provides only a brief snapshot of SHS exposure, and it is possible that the actual exposure rate is higher or lower. It is noteworthy that, due to sample size variations and availability, only a small number of samples were available in some of the groups, which could impact the results. Repeating the study with larger case number from each area would be helpful. In addition, as the study was performed on left-over samples, the specific characteristics such as indoor/outdoor, house size, sex and age were not recorded; these could impact the results. For example, a primarily free-roaming cat would be expected to have limited SHS exposure, while a small breed dog in a studio apartment with a heavy smoker could be expected to a much higher exposure. Finally, it is not known why the samples were collected, so it is possible that an underlying illness could impact the results. It is important to note, as a further limitation, that SES distinction by ZIP code can misclassify individuals but has been similarly used in human healthcare studies.

Conclusion

Community veterinary healthcare workers should recognize that a higher rate of exposure to SHS is likely in companion animals. Information about potential risks to humans and animals should be discussed, as quitting entirely or reducing exposure will improve health in people and likely pets. Due to the ease of screening, routine assessment of a pet's exposure level could be incorporated to facilitate more conversations. While the increased rate of tobacco smoking in lower SES is well-recognized, the community medicine veterinary team can introduce the concept SHS smoke with potential risk to pets and ideally help improve health for all family members.

Authors' contributions

NS: Data curation, Formal analysis, Writing – original draft. ER: Conceptualization, Project administration, Supervision, Writing – review & editing.

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Authors' notes

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