U.S. EPA Region 4 Radon Stakeholder Meeting

April 16-17, 2024 (Charlotte, NC)

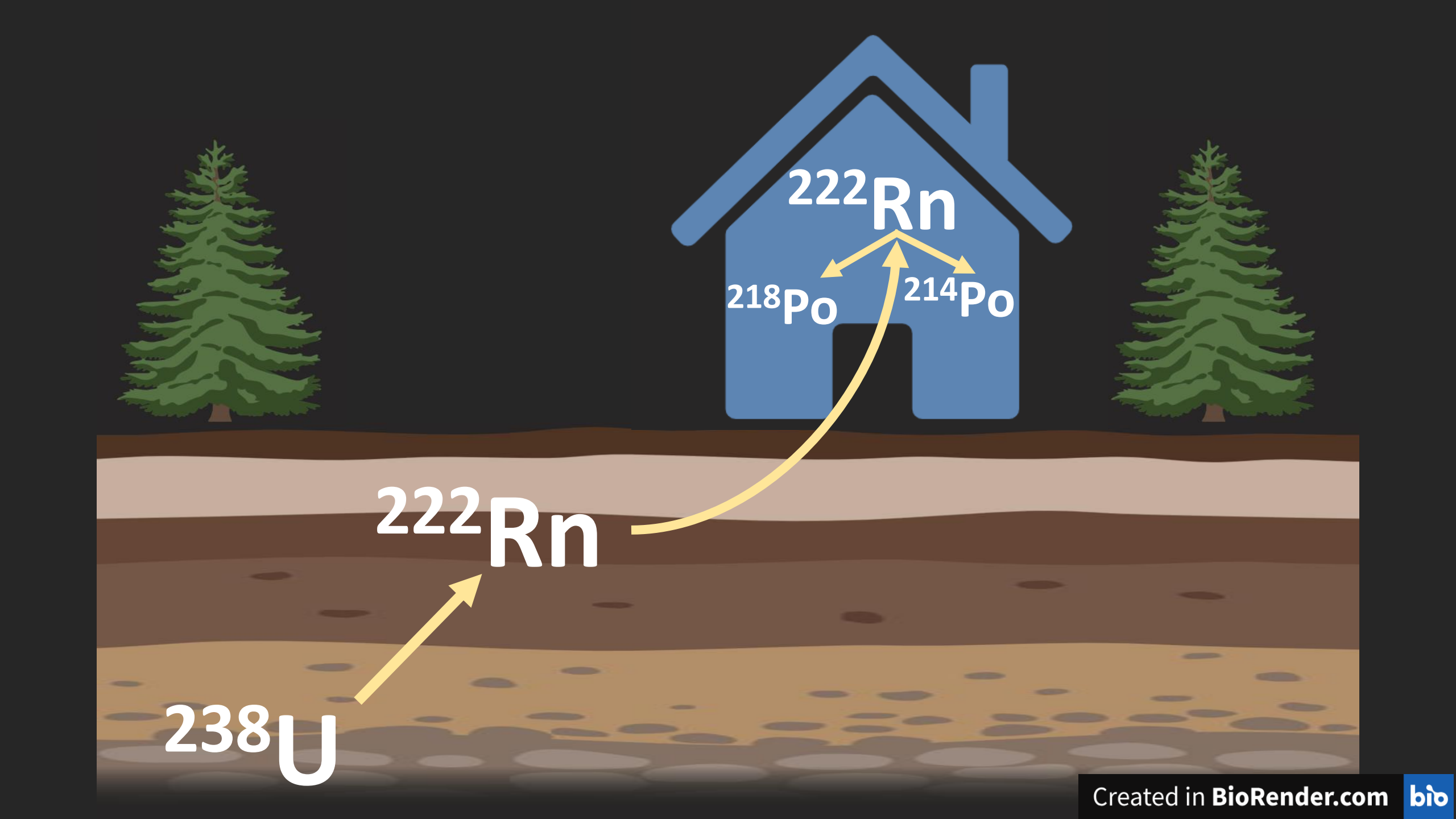
NC STATE UNIVERSITY College of Veterinary Medicine

Radon:
Canine and Feline Health Impacts

Michael Nolan, DVM, PhD, Diplomate ACVR (RO)

Interim Department Head *and* Professor of Radiation Oncology

NC State University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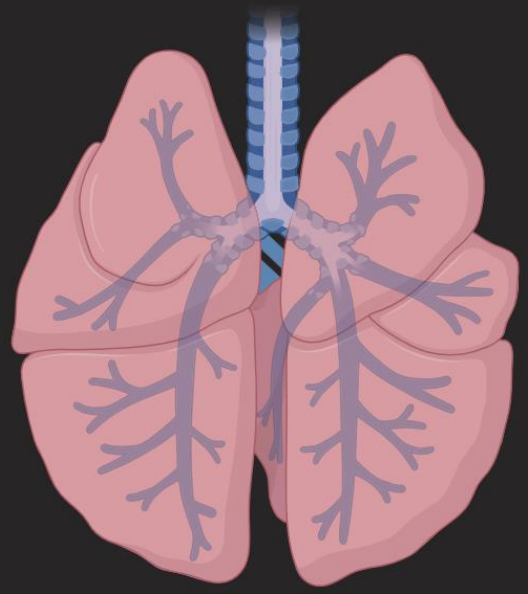

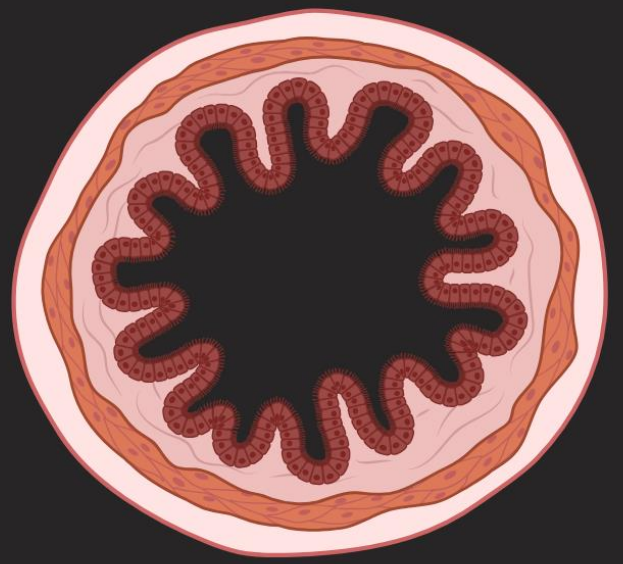

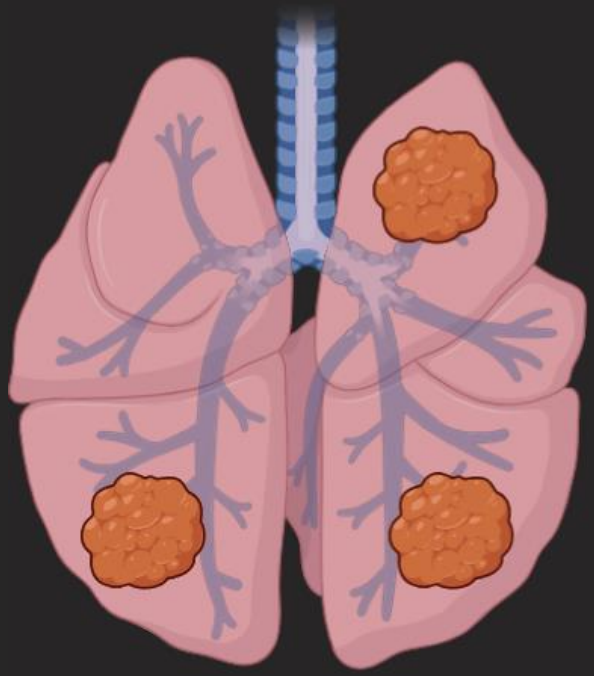

What is known about the risk of radon-induced disease in *pet animals* who share our home environment?

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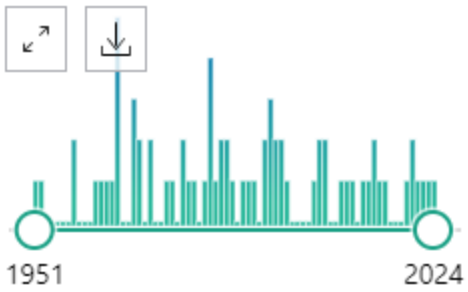
RESULTS BY YEAR



70 results

Page 1 of 7

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Environmental **radon**, fracking wells, and lymphoma in **dogs**.

Tindle AN, Braman SL, Swafford BM, Trepanier LA.

J Vet Intern Med. 2024 Mar 4. doi: 10.1111/jvim.17021. Online ahead of print.

PMID: 38437620 Free article.

BACKGROUND: Multicentric lymphoma (ML) in **dogs** resembles non-Hodgkin lymphoma (NHL) in humans. Human NHL is associated with multiple environmental exposures, including to **radon** and volatile organic compounds (VOCs). HYPOTHESIS/OBJECTIVES: The objective of this study ...

RADIATION RESEARCH 8, 417–437 (1958)

Radium (Ra^{226}) and Radon (Em^{222}) Metabolism in Dogs[1]

M. A. VAN DILLA,[2] B. J. STOVER, R. L. FLOYD,[3] D. R. ATHERTON, AND D. H. TAYSUM

Radiobiology Laboratory, College of Medicine, University of Utah, Salt Lake City, Utah

RADIATION RESEARCH 73, 274–287 (1978)

Variation of Radon Retention Parameters for Radium-Burdened Dog Skeletons as a Function of Exposure Age and Dosage Level[1]

N. J. PARKS, R. R. POOL, AND J. R. WILLIAMS

Radiobiology Laboratory, School of Veterinary Medicine, University of California, Davis, California 95616

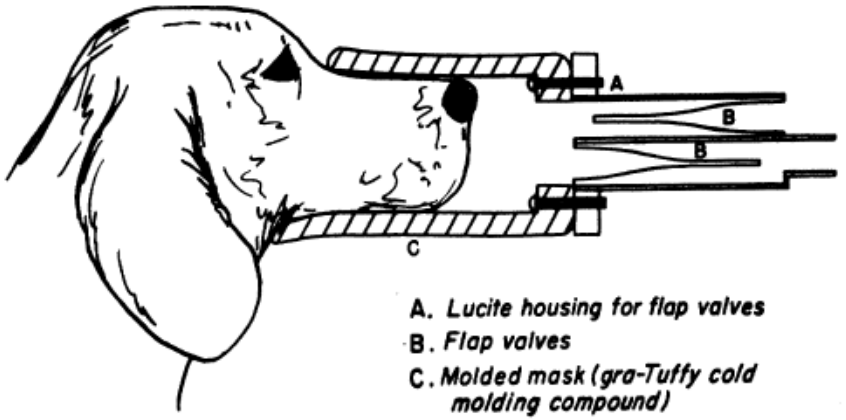

FIG. 2. Face mask used to collect breath sample from beagle.

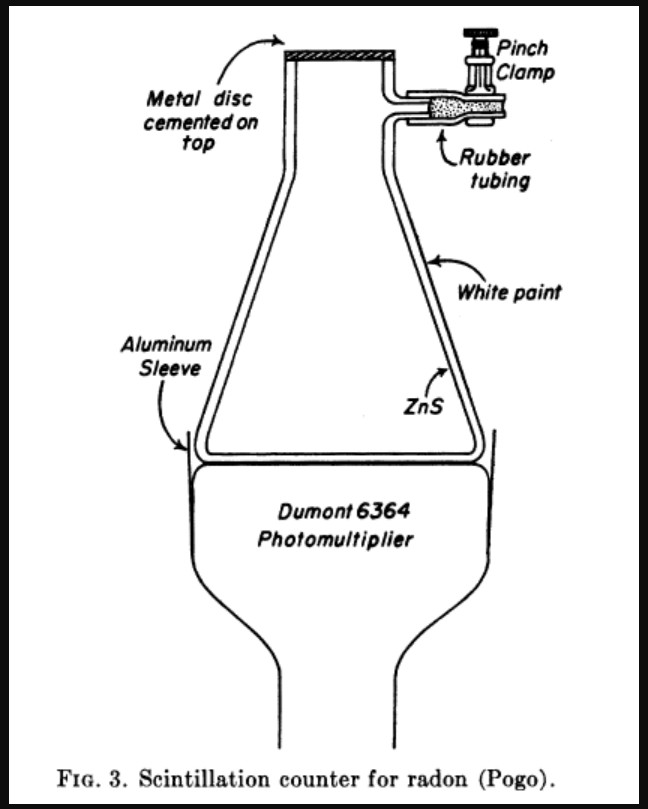

FIG. 3. Scintillation counter for radon (Pogo).

Health Physics, Vol. 42, No. 1, (January) pp. 33–52, 1982
Printed in the U.S.A.

0017–9078/82/010033–20$03.00/0
Pergamon Press Ltd.

CARCINOGENIC EFFECTS OF RADON DAUGHTERS, URANIUM ORE DUST AND CIGARETTE SMOKE IN BEAGLE DOGS

F. T. CROSS, R. F. PALMER, R. E. FILIPY, G. E. DAGLE and B. O. STUART*
Biology Department, Pacific Northwest Laboratory, Richland, WA 99352

Table 1. Experimental design for dog studies

Group No.(a)	No. of Animals(b)	Exposure
1	20	Radon, radon daughters, and uranium ore dust
2	20	Radon, radon daughters, uranium ore dust and cigarette smoke
3	20	Cigarette smoke
4	9	Room air

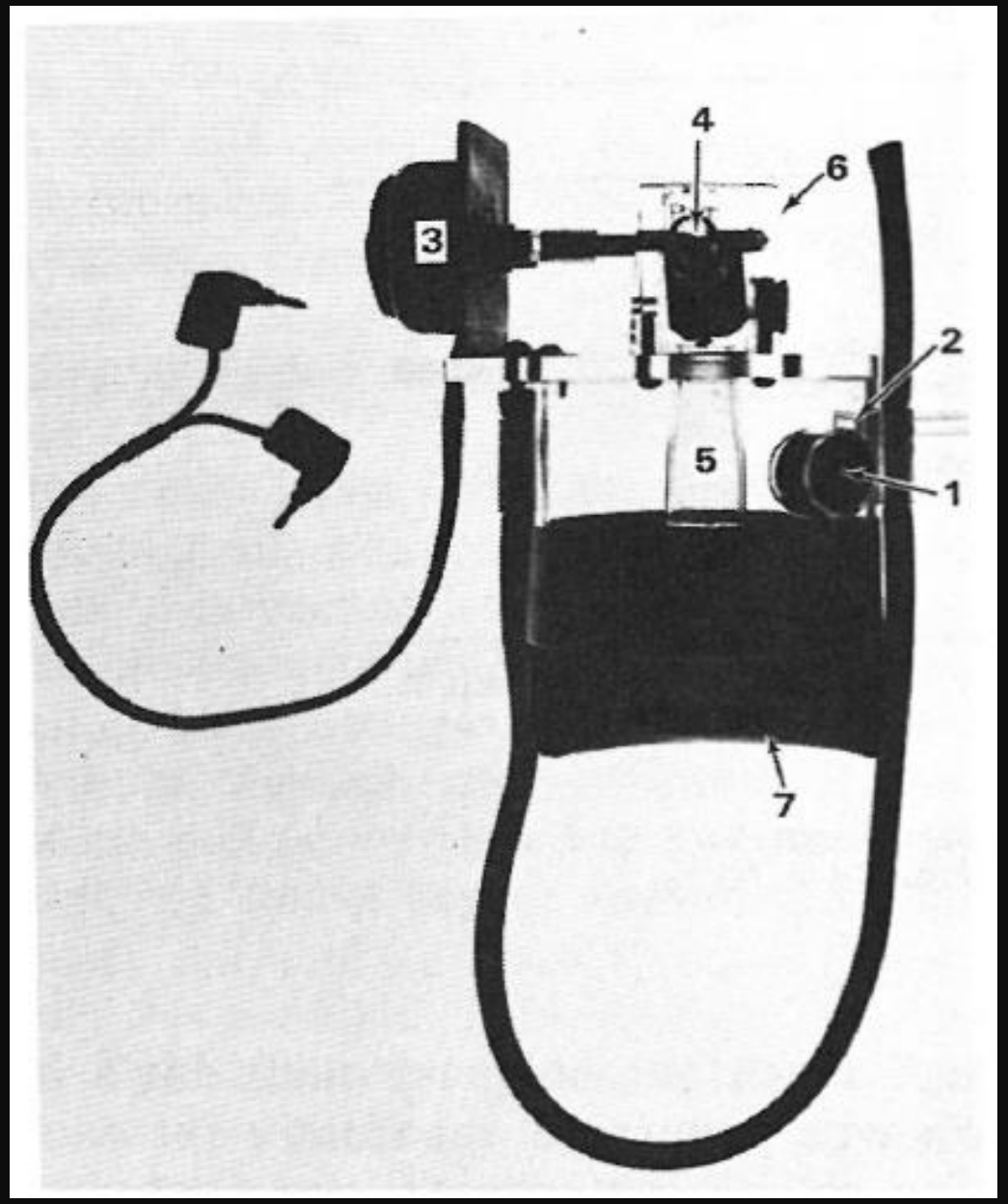

Table 1. Experimental design for dog studies

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3	20	Cigarette smoke
4	9	Room air

Table 8. Tumors primary to the respiratory tract of dogs exposed to radon daughters

Group No.	No. Animals in Group	No. Animals with Tumors	% Tumors	Mean Survival Time (Days, ± SD)
1	19			1500(250)
		2 nose	11	1575(191)
		7 lung	37	1714(146)
		8 total[a]	42	1680(170)

RADIATION RESEARCH **152**, S19–S22 (1999)
0033-7587/99 $5.00

Comparative Stochastic Effects of Inhaled Alpha- and Beta-Particle-Emitting Radionuclides in Beagle Dogs

Fletcher F. Hahn, Bruce A. Muggenburg, Raymond A. Guilmette and Bruce B. Boecker

Lovelace Respiratory Research Institute, P.O. Box 5890, Albuquerque, New Mexico 87185

TABLE 3
Occurrence of Lung Neoplasms by Histological Classification in Dogs That Inhaled $^{239}PuO_2$ or ^{144}Ce FAP[a]

	$^{239}PuO_2$	^{144}Ce FAP	Controls
Total number of neoplasms	178	32	40
Incidence of lung neoplasm type			
Adenoma	10%	6.2%	10%
Adenocarcinoma	40%	31%	50%
Carcinoma	47%	25%	37%
Bronchioloalveolar	27%	19%	13%
Adenosquamous	12%	3.0%	12%
Squamous cell	7.0%	3.0%	0
Bronchial gland	1.0%	0	2.0%
Carcinosarcoma	2.2%	9.4%	0
Sarcoma	0.6%	28%	2.0%

[a] ^{144}Ce in fused aluminosilicate particles.

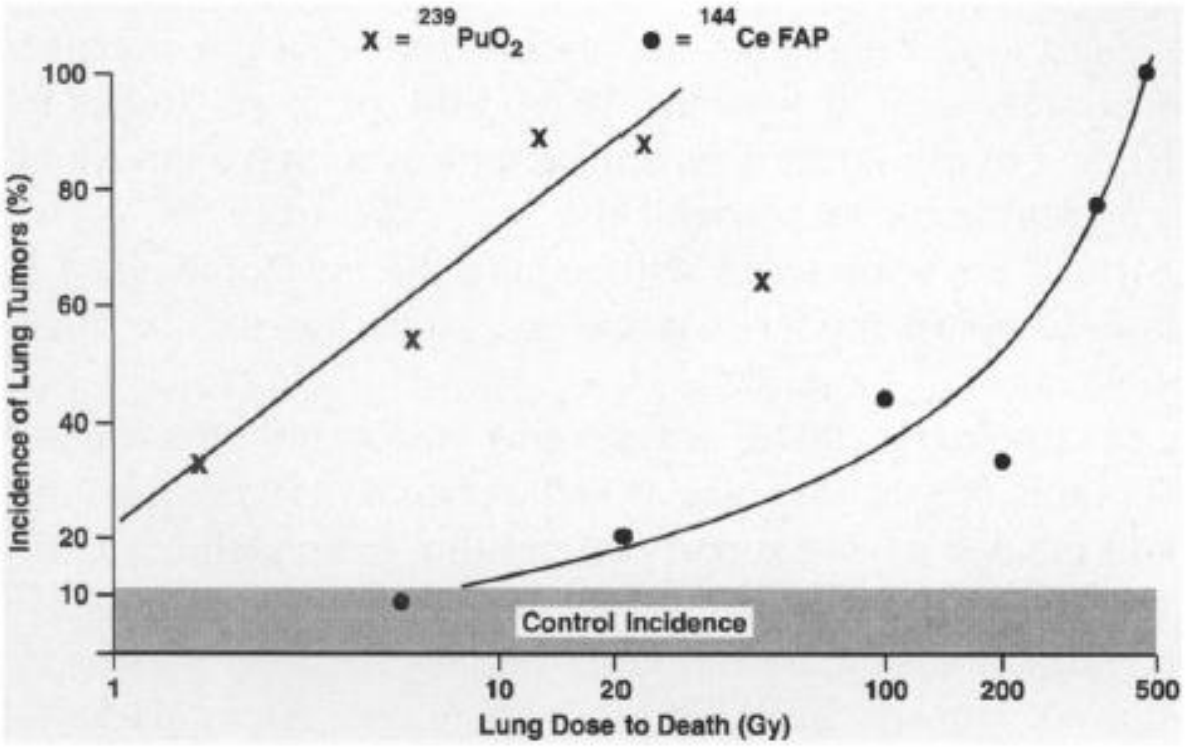

FIG. 1. Dose–response relationship for lung neoplasms in dogs that inhaled $^{239}PuO_2$ or ^{144}Ce in fused aluminosilicate particles. Curves are eye-drawn fits.

Threshold for Radon-Induced Lung Cancer From Inhaled Plutonium Data

Dose-Response:
An International Journal
October-December 2015:1-4

DOI: 10.1177/1559325815615102
dos.sagepub.com
SAGE

Jerry M. Cuttler[1] and Charles L. Sanders[2]

Abstract

Cohen's lung cancer mortality data, from his test of the LNT theory, do not extend to the no observed adverse effects level (NOAEL) above which inhaled radon decay products begin to induce excess lung cancer mortality. Since there is concern about the level of radon in homes, it is important to set the radon limit near the NOAEL to avoid the risk of losing a health benefit. Assuming that dogs model humans, data from a study on inhaled plutonium dioxide particulates in dogs were assessed, and the NOAEL for radon-induced lung tumors was estimated to be about 2100 Bq/m^3. The US Environmental Protection Agency should consider raising its radon action level from 150 to at least 1000 Bq/m^3.

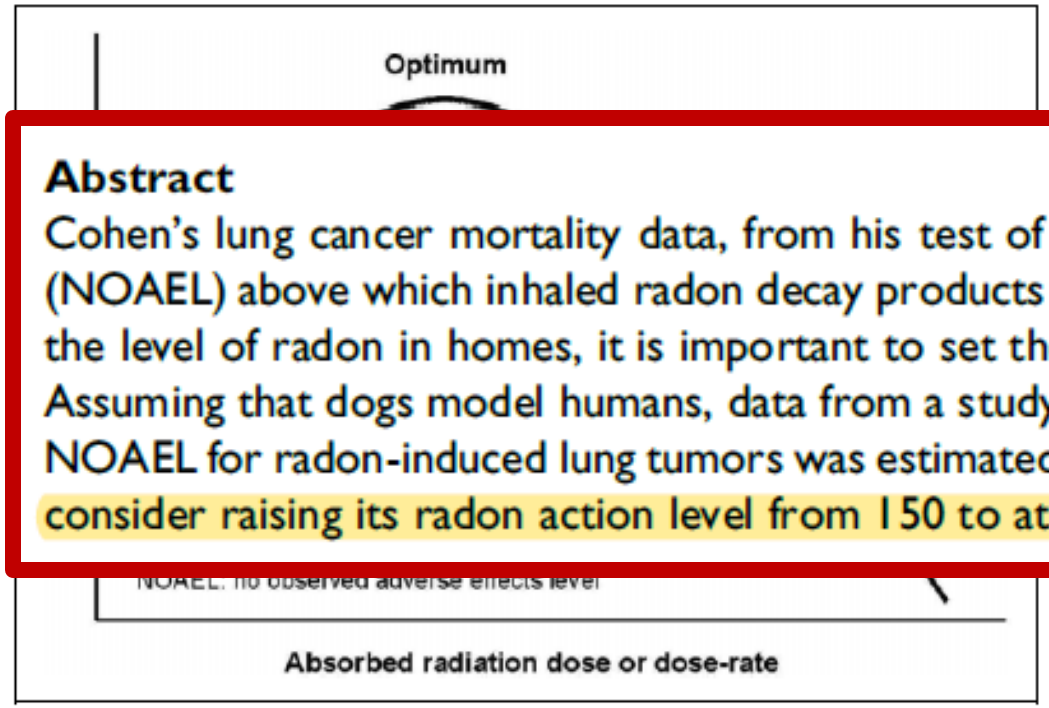

Figure 1. Radiation hormesis model showing the no observed adverse effects level (NOAEL) for excess cancer mortality.

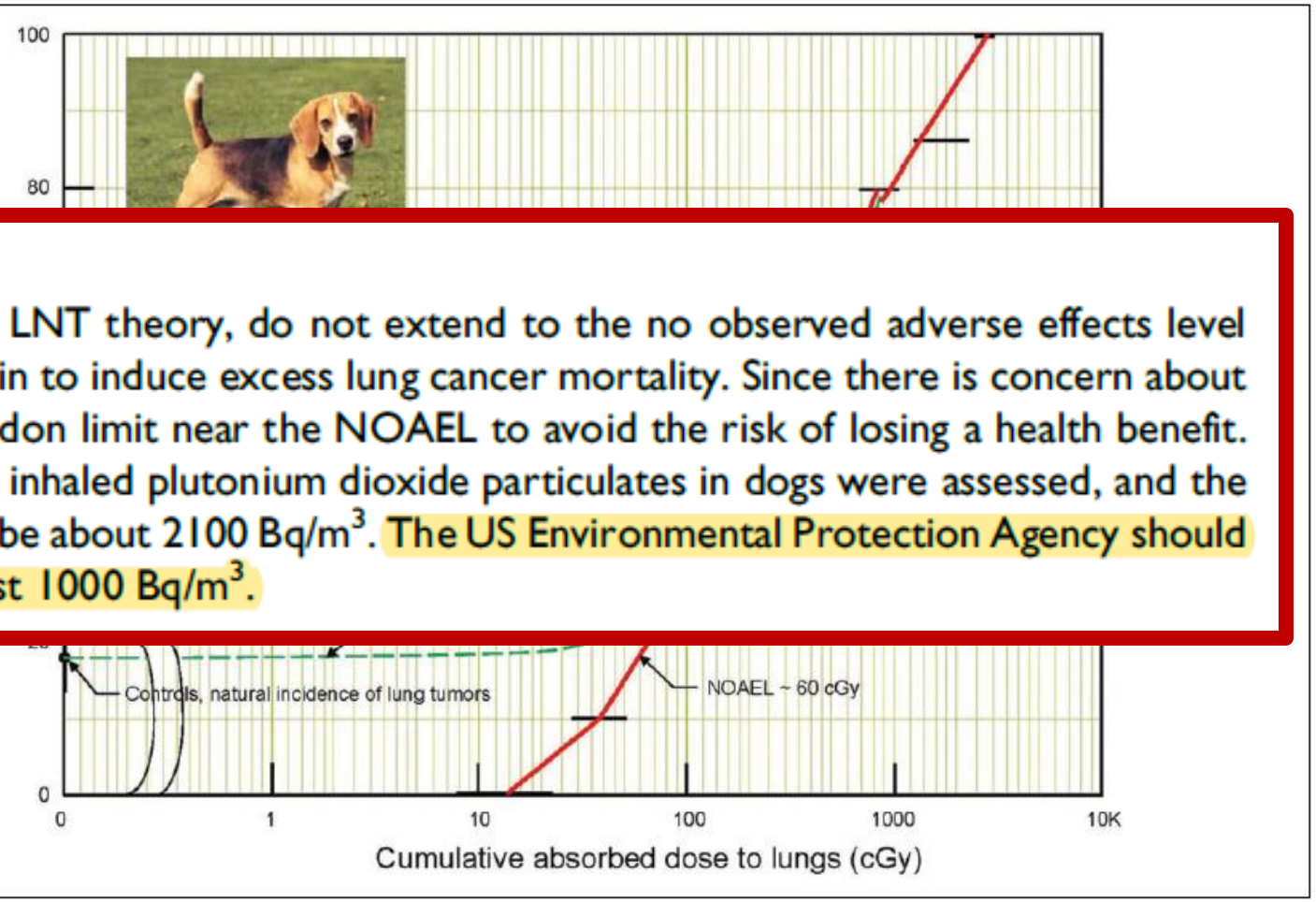

Figure 2. Lung tumor incidence versus cumulative absorbed dose to lungs for dogs that inhaled $^{239}PuO_2$ particulates (adapted from Fisher and Weller,[8] figures 3 and 4).

RADIATION RESEARCH **145**, 181–187 (1996)
0033-7587/96 $5.00

p53, *erb*B-2 and K-*ras* Gene Alterations Are Rare in Spontaneous and Plutonium-239-Induced Canine Lung Neoplasia

Lauren A. Tierney, Fletcher F. Hahn and John F. Lechner[1]

Inhalation Toxicology Research Institute, P.O. Box 5890, Albuquerque, New Mexico 87185

TABLE II

p53 and *erb*B-2 Abnormalities in Canine Lung Tumors as Determined by Immunohistochemistry

Histological phenotype	Exposure status	Gene dysfunction			
		p53	(Percentage)	*erb*B-2	(Percentage)
Papillary adenocarcinoma	$^{239}PuO_2$ exposed	0/26	(0)	5/25	(20)
	unexposed	0/24	(0)	1/24	(4)
Bronchioloalveolar carcinoma	$^{239}PuO_2$ exposed	0/21	(0)	0/22	(0)
	unexposed	1/7	(14)	2/7	(29)
Squamous cell carcinoma	$^{239}PuO_2$ exposed	6/19	(32)	5/19	(26)
	unexposed	2/2	(100)	0/2	(0)
Adenosquamous carcinoma	$^{239}PuO_2$ exposed	4/12	(33)	6/13	(46)
	unexposed	3/4	(75)	1/4	(25)
Large cell carcinoma[a]	$^{239}PuO_2$ exposed	0/1	(0)	1/1	(100)
	unexposed	0/0	—	0/0	—

[a]Large cell carcinoma not represented in unexposed dogs examined.

NATIONAL ACADEMIES Sciences Engineering Medicine

Companion Animals as Sentinels for Predicting Environmental Exposure Effects on Aging and Cancer Susceptibility in Humans

Proceedings of a Workshop

DOI: 10.1111/jvim.17021

STANDARD ARTICLE

Journal of Veterinary Internal Medicine Open Access

ACVIM American College of Veterinary Internal Medicine

Environmental radon, fracking wells, and lymphoma in dogs

Ashleigh N. Tindle[1] | Samantha L. Braman[1] | Brenna M. Swafford[2] | Lauren A. Trepanier[1]

J Vet Intern Med. 2024;1–7.

FIGURE 1 Chloropleth maps showing geographic distribution of golden retrievers (GRs) with lymphoma (A) and matched unaffected controls (B) recruited through the longitudinal Golden Retriever Lifetime Study.[30] Color intensity increases with a higher percentage of each segment of the study groups from each state.

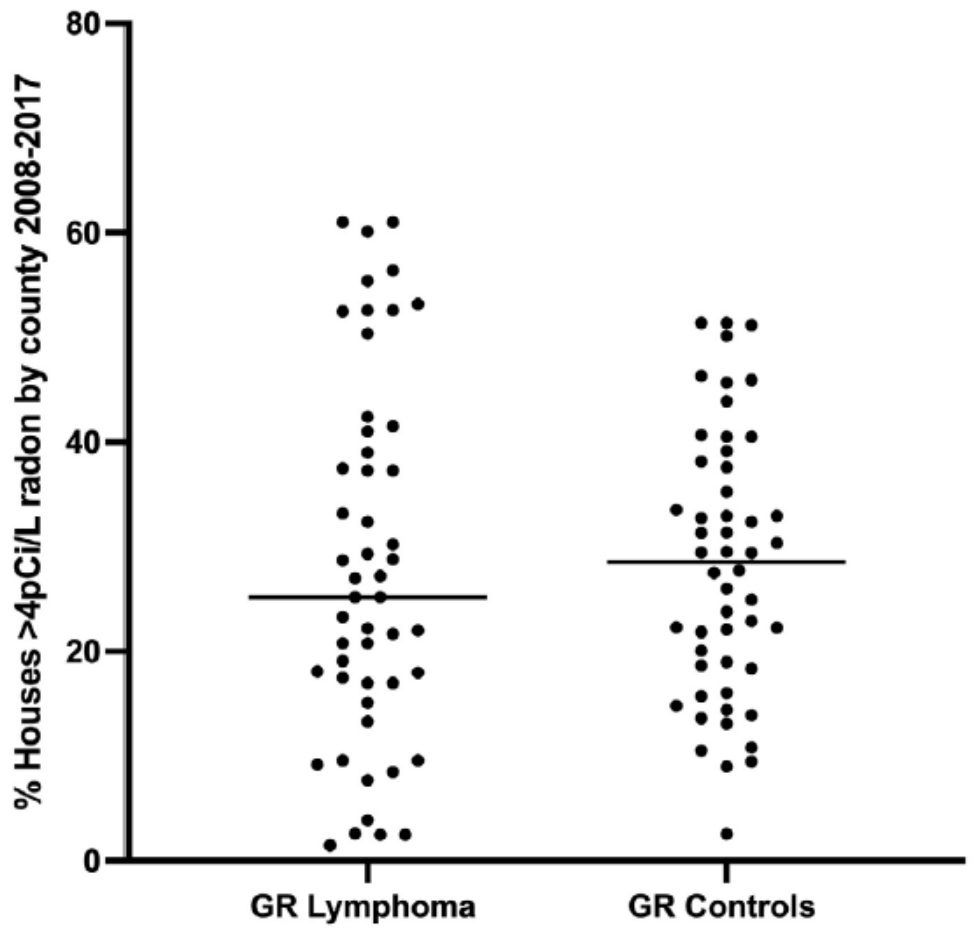

FIGURE 2 Percentage of tested homes with radon levels >4pCi/L (EPA action threshold) by county of residence for golden retriever (GR) dogs with multicentric lymphoma compared to unaffected controls. Scatter plots throughout show each dog as an individual data point, with medians indicated by horizontal bars.

Geographic distribution and environmental risk factors of lymphoma in dogs under primary-care in the UK

I. Schofield[1,*], K. B. Stevens*, C. Pittaway[†], D. G. O'Neill[*], D. Fecht[‡], J. M. Dobson[†] and D. C. Brodbelt*

Journal of Small Animal Practice (2019) **60**, 746–754
DOI: 10.1111/jsap.13075

Table 1. Descriptive and univariable logistic regression analysis of environmental risk factors in dogs with a laboratory confirmation of lymphoma and all dogs with lymphoma (with and without laboratory confirmation), attending UK primary care veterinary practices in 2013

Variable	Non-cases (%)	Laboratory confirmed cases (%)	Odds ratio (95% confidence intervals)	LRT P-value	All cases (%)	Odds ratio (95% confidence intervals)	LRT P-value
Age (years)				0.001			<0.001
<8	168,407 (62.20)	91 (48.92)	-		105 (38.32)	-	
8 to <12	69,394 (25.63)	66 (35.48)	1.76 (1.28 to 2.42)		112 (40.88)	2.59 (1.98 to 3.38)	
≥12	32,934 (12.16)	29 (15.59)	1.63 (1.07 to 2.48)		57 (20.80)	2.78 (2.01 to 3.83)	
Breed				<0.001			<0.001
Crossbreed	61,050 (22.61)	47 (25.27)	-		75 (27.27)	-	
Other purebreed	81,179 (30.07)	37 (19.89)	0.59 (0.38 to 0.91)		53 (19.27)	0.53 (0.37 to 0.76)	
Border collie	8855 (3.28)	5 (2.69)	0.73 (0.29 to 1.84)		8 (2.91)	0.74 (0.35 to 1.53)	
Boxer	4259 (1.58)	12 (6.45)	3.66 (1.94 to 6.90)		15 (5.45)	2.87 (1.65 to 5.00)	
Bull terrier	1197 (0.44)	4 (2.15)	4.34 (1.56 to 12.07)		5 (1.82)	3.40 (1.37 to 8.42)	
Cavalier King Charles spaniel	6901 (2.56)	6 (3.23)	1.13 (0.48 to 2.64)		7 (2.55)	0.83 (0.38 to 1.79)	
Cocker spaniel	10,205 (3.78)	7 (3.76)	0.89 (0.40 to 1.97)		7 (2.55)	0.56 (0.26 to 1.21)	
Dogue de Bordeaux	782 (0.29)	2 (1.09)	3.32 (0.81 to 13.70)		4 (1.45)	4.16 (1.52 to 11.41)	
German shepherd dog	8047 (2.98)	8 (4.30)	1.29 (0.61 to 2.73)		12 (4.36)	1.21 (0.66 to 2.23)	
Golden retriever	3944 (1.46)	4 (2.15)	1.32 (0.47 to 3.66)		8 (2.91)	1.65 (0.80 to 3.43)	
Jack Russell terrier	19,578 (7.25)	7 (3.76)	0.46 (0.21 to 1.03)		12 (4.36)	0.50 (0.27 to 0.92)	
Labrador retriever	22,119 (8.19)	9 (4.84)	0.53 (0.26 to 1.08)		12 (4.36)	0.44 (0.24 to 0.81)	
Lurcher	2099 (0.78)	5 (2.69)	3.09 (1.23 to 7.79)		6 (2.18)	2.33 (1.01 to 5.35)	
Schnauzer	2861 (1.06)	5 (2.69)	2.27 (0.90 to 5.71)		5 (1.82)	1.42 (0.57 to 3.52)	
Scottish terrier	672 (0.25)	3 (1.61)	5.80 (1.90 to 18.68)		4 (1.45)	4.84 (1.77 to 13.29)	
Springer spaniel	7563 (2.80)	4 (2.15)	0.69 (0.25 to 1.91)		8 (2.91)	0.86 (042 to 1.79)	
Staffordshire bull terrier	19,353 (7.17)	9 (4.84)	0.60 (0.30 to 1.23)		17 (6.18)	0.72 (0.42 to 1.21)	
West Highland white terrier	9308 (3.45)	12 (6.45)	1.67 (0.89 to 3.16)		17 (6.18)	1.49 (0.88 to 2.52)	
Weight (kg)				<0.001			<0.001
Unknown	27,012 (9.98)	9 (4.84)	0.30 (0.15 to 0.61)		27 (9.78)	0.66 (0.43 to 1.02)	
<10	67,158 (24.81)	16 (8.60)	0.22 (0.13 to 0.38)		23 (8.33)	0.23 (0.14 to 0.36)	
10 to <20	67,516 (24.94)	49 (26.34)	0.66 (0.46 to 0.97)		75 (27.71)	0.73 (0.54 to 1.00)	
20 to <30	52,299 (19.32)	50 (26.88)	0.88 (0.60 to 1.27)		65 (23.55)	0.82 (0.59 to 1.13)	
≥30	56,750 (20.96)	62 (33.33)	-		86 (31.16)	-	
Maximum radon potential (% of homes>200 Bq/m^3)							
<1	165,352 (64.31)	121 (67.22)	-	0.83	165 (61.34)	-	0.73
1 to <3	53,045 (20.63)	37 (20.56)	0.95 (0.66 to 1.38)		62 (23.05)	1.17 (0.87 to 1.57)	
3 to <5	16,148 (6.28)	8 (4.44)	0.68 (0.33 to 1.38)		20 (7.43)	1.24 (0.78 to 1.97)	
5 to <10	13,647 (5.31)	8 (4.44)	0.80 (0.39 to 1.64)		11 (4.09)	0.81 (0.44 to 1.49)	
10 to <30	6285 (2.44)	5 (2.78)	1.09 (0.44 to 2.66)		8 (2.97)	1.28 (0.63 to 2.59)	
≥30	2625 (1.02)	1 (0.56)	0.52 (0.07 to 3.73)		3 (1.12)	1.15 (0.37 to 3.59)	

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STANDARD ARTICLE

Journal of Veterinary Internal Medicine Open Access
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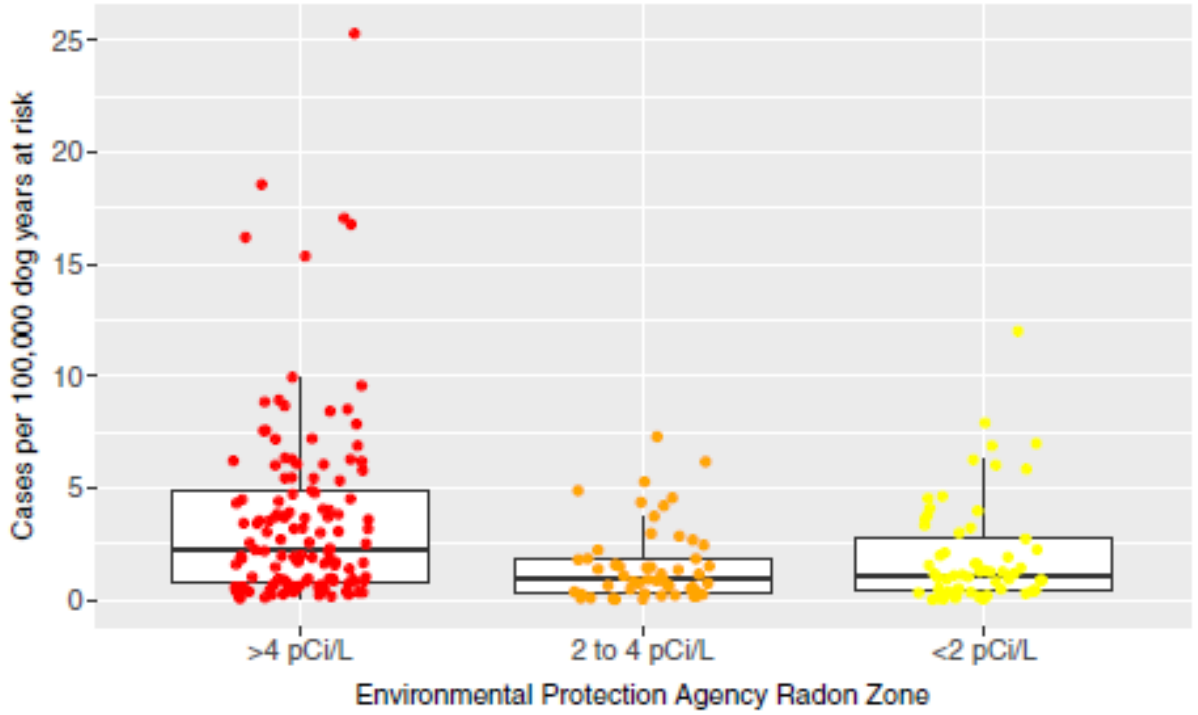
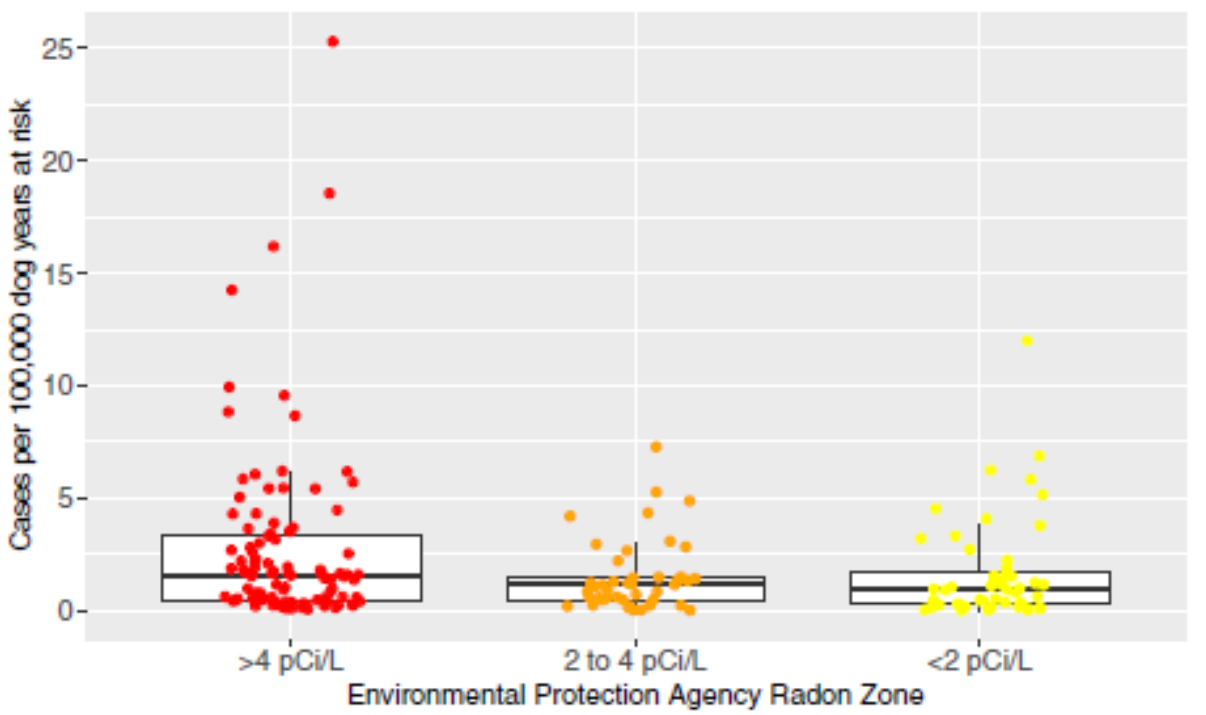
Ecological level analysis of primary lung tumors in dogs and cats and environmental radon activity

Brittany L. Fowler[1] | Chad M. Johannes[1] | Annette O'Connor[1] | Deanna Collins[1] | Jonathan Lustgarten[2] | Chaohui Yuan[1] | Kristen Weishaar[3] | Kelly Sullivan[4] | Kelly R. Hume[4] | Jennifer Mahoney[5] | Brittany Vale[6] | Alicia Schubert[7] | Valerie Ball[7] | Katie Cooley-Lock[8] | Kaitlin M. Curran[9] | Laura Nafe[10] | Allison Gedney[10] | Megan Weatherford[11] | Dana N. LeVine[1]





NATIONAL ACADEMIES Sciences Engineering Medicine

Companion Animals as Sentinels for Predicting Environmental Exposure Effects on Aging and Cancer Susceptibility in Humans

Proceedings of a Workshop

An Alternative Approach for Investigating the Carcinogenicity of Indoor Air Pollution: Pets as Sentinels of Environmental Cancer Risk

John A. Bukowski and Daniel Wartenberg

Volume 105, Number 12, December 1997 • Environmental Health Perspectives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