Epidemiological Studies of Human Lung Cancer

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Residential Radon and Lung Cancer

Early large-scale case-control study

American Journal of Epidemiology
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ORIGINAL CONTRIBUTIONS

Case-Control Study of Residential Radon and Lung Cancer in Winnipeg, Manitoba, Canada

E. G. Létourneau,[1] D. Krewski,[1,2] N. W. Choi,[3,4] M. J. Goddard,[1] R. G. McGregor,[1] J. M. Zielinski,[1] and J. Du[3]

750 cases-control pairs
in city with highest radon levels in Canada
with multiple one year integrated radon measurements in all homes

TABLE 4. Odds ratios for residential radon exposure and lung cancer based on cumulative radon exposure in all residences occupied: Winnipeg, Manitoba, Canada, 1992

Area monitored and cumulative radon exposure (Bq/m^3-years)	All participants				At least 75% coverage*			
	No. of cases	No. of controls	OR†,‡	95% CI†	No. of cases	No. of controls	OR	95% CI
5–30 years before enrollment in the study								
Bedroom								
0–1,800	92	84	1.0		51	38	1.0	
1,801–3,600	488	453	0.97	0.63–1.48	93	102	0.61	0.31–1.22
3,601–7,200	118	153	0.84	0.51–1.39	64	68	0.76	0.37–1.56
≥7,201	40	48	1.00	0.69–1.46	19	19	1.56	0.92–2.66
Basement								
0–2,800	108	93	1.0		52	44	1.0	
2,801–5,600	494	487	0.82	0.55–1.22	109	115	0.76	0.42–1.37
5,601–11,200	106	113	0.85	0.51–1.41	49	46	0.90	0.43–1.89
≥11,201	30	45	0.60	0.42–0.86	17	22	1.03	0.65–1.62

Large case-control study with extensive exposure monitoring fails to identify lung cancer risk

Residential Radon and Lung Cancer

ORIGINAL ARTICLE

Epidemiology (2005), V16, pp. 137-145

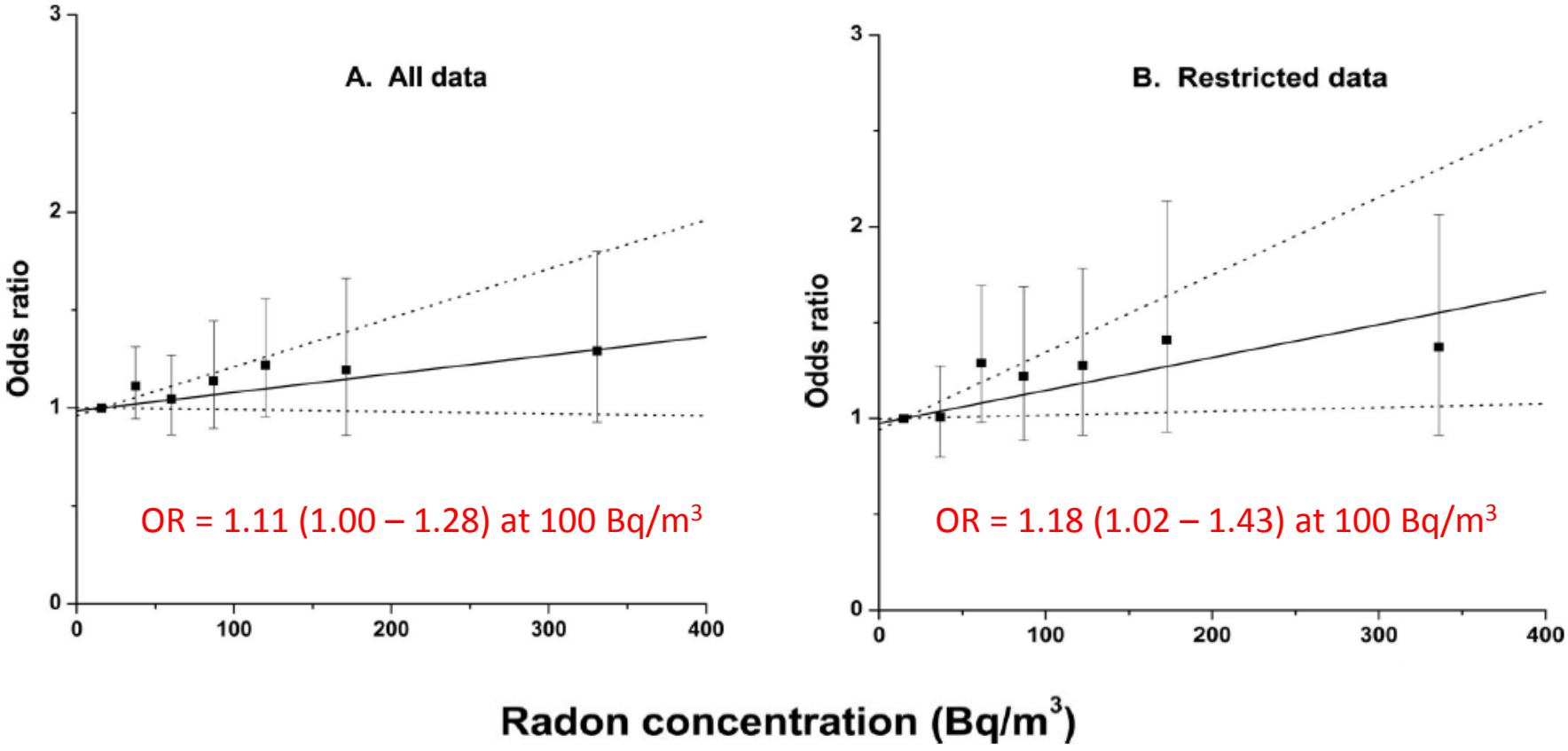
Residential Radon and Risk of Lung Cancer

A Combined Analysis of 7 North American Case-Control Studies

Daniel Krewski,[*] Jay H. Lubin,[†] Jan M. Zielinski,[‡] Michael Alavanja,[§] Vanessa S. Catalan,[‖] R. William Field,[**¶] Judith B. Klotz,[††] Ernest G. Létourneau,[‡‡] Charles F. Lynch,[¶] Joseph I. Lyon,[§§] Dale P. Sandler,[‖‖] Janet B. Schoenberg,[††] Daniel J. Steck,[¶¶] Jan A. Stolwijk,[***] Clarice Weinberg,[†††] and Homer B. Wilcox[††]*

Combining data from multiple studies identifies lung cancer risk

Exposure-response Relationships for Radon and Lung Cancer



Reducing measurement error increases lung cancer risk estimate

TABLE 4. Excess Odds Ratios* for Lung Cancer Per 100 Bq/M^3 Radon in the 5- to 30-Year Exposure Time Window by Histologic Type

Histologic Type	No. of Cases (n = 3662)	Excess Odds Ratio (95% CI)
Adenocarcinoma	1380	0.09 (−0.05–0.35)
Squamous cell	799	0.09 (−0.04–0.42)
Small/oat cell	577	0.23 (−0.08–0.88)
Other	740	0.19 (−0.02–0.62)
Unknown	166	−0.16 (——0.06)
All	3662	0.11 (0.00–0.28)

No specific histological type of lung cancer linked to radon

Recent large-scale cohort study

Published OnlineFirst January 6, 2011; DOI:10.1158/1055-9965.EPI-10-1153

Cancer Epidemiology, Biomarkers & Prevention

Research Article

Radon and Lung Cancer in the American Cancer Society Cohort

Michelle C. Turner[1,2], Daniel Krewski[2,3,4], Yue Chen[3], C. Arden Pope III[5], Susan Gapstur[6], and Michael J. Thun[6]

811,961 participants in American Cancer Society CPS-II Study followed from 1982 to 1988;
radon exposure based on county level radon surveys

Table 3. Adjusted HRs (95% CIs) for lung cancer mortality in relation to mean county-level residential radon concentrations (LBL; Bq/m^3) at enrollment (1982), follow-up 1982–1988, CPS-II cohort, United States

Radon concentration (Bq/m^3)	Lung cancer deaths	Person-years	Death rate[a]	Minimally adjusted HR (95% CI)[b]	Fully adjusted HR (1) (95% CI)[c]	Fully adjusted HR (2) (95% CI)[d]
Categorical						
<25	856	1,062,216.23	77.79	1.00	1.00	1.00
25-<50	1,312	1,767,001.74	75.59	0.97 (0.89–1.06)	0.96 (0.88–1.04)	1.01 (0.90–1.13)
50-<75	632	863,881.31	74.09	0.96 (0.86–1.06)	1.00 (0.90–1.10)	1.03 (0.89–1.19)
75-<100	274	428,430.94	64.47	0.82 (0.72–0.94)	0.90 (0.79–1.03)	0.97 (0.82–1.16)
100-<150	332	526,638.30	62.49	0.80 (0.70–0.90)	0.97 (0.85–1.10)	1.15 (0.95–1.39)
150-<200	53	62,903.34	83.53	1.07 (0.81–1.41)	1.27 (0.96–1.68)	1.53 (1.10–2.13)
≥200	34	42,084.48	82.20	1.07 (0.76–1.50)	1.24 (0.88–1.75)	1.38 (0.95–2.00)
P_{trend}[e]				*0.006*	*0.44*	*0.02*
EPA guideline value						
<148	3,396	4,631,071.50	73.31	1.00	1.00	1.00
≥148	97	122,084.84	80.82	1.10 (0.90–1.34)	1.24 (1.02–1.52)	1.34 (1.07–1.68)
Continuous						
per 100 Bq/m^3	3,493	4,753,156.34	73.49	0.88 (0.80–0.96)	1.03 (0.94–1.13)	1.15 (1.01–1.31)

Ecologic measure of radon, adjusting for individual smoking habits, confirms residential radon lung cancer risk

Comparison of Radon Risk Estimates

Study Population	Odds/Hazard Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Occupational Cohort Studies		
Underground Miners (NRC, 1999)	1.12 (1.02 – 1.25)	
Residential Case-control Studies		
North American Residential (Krewski et al., 2005, 2006)	1.11 (1.00 – 1.28)	1.18 (1.02 - 1.43)
European Residential (Darby et al., 2005)	1.08 (1.03 – 1.16)	1.16 (1.05 – 1.31)
Chinese Residential (Lubin et al., 2004)	1.33 (1.01 – 1.36)	
Residential Cohort Studies		
North American Residential (Turner et al., 2011)	1.15 (1.01 – 1.31)	

Radon risk estimates highly consistent across diverse studies

Particulate Air Pollution ($PM_{2.5}$)

The NEW ENGLAND JOURNAL of MEDICINE

Krewski (2009), V360, pp. 413-415

Table 1. Estimates of Increased Mortality Associated with an Increase in $PM_{2.5}$ Concentrations of 10 μg per Cubic Meter Based on Extended Follow-up of the American Cancer Society Cancer Prevention Study II.*

Cause of Death	Krewski et al., 2000†	Pope et al., 2002‡		Krewski et al., 2008§	
	$PM_{2.5}$ Monitoring 1979–1983, Follow-up 1989	$PM_{2.5}$ Monitoring 1979–1983, Follow-up 1998	$PM_{2.5}$ Monitoring 1999–2000, Follow-up 1998	$PM_{2.5}$ Monitoring 1979–1983, Follow-up 2000	$PM_{2.5}$ Monitoring, 1999–2000, Follow-up 2000
	percent increase in mortality (95% CI)				
All causes	4.8 (2.2 to 7.6)	3.1 (1.5 to 4.7)	3.2 (1.2 to 5.3)	2.8 (1.4 to 4.3)	3.6 (1.7 to 5.4)
Cardiopulmonary disease	10.1 (6.1 to 14.3)	7.1 (4.8 to 9.5)	9.2 (6.3 to 12.3)	7.0 (4.9 to 9.2)	10.0 (7.3 to 12.9)
Ischemic heart disease	12.2 (6.6 to 18.1)	13.0 (9.4 to 16.6)	14.3 (9.9 to 19.0)	13.3 (10.0 to 16.7)	15.5 (11.3 to 19.9)
Lung cancer	5.3 (–3.7 to 15.0)	8.9 (3.1 to 15.1)	11.6 (4.1 to 19.7)	7.5 (2.1 to 13.2)	10.9 (3.9 to 18.5)
All other causes	–0.2 (–4.2 to 4.0)	–1.9 (–4.3 to 0.5)	–4.7 (–7.6 to 1.8)	–2.1 (–4.3 to 0.0)	–4.7 (–7.3 to 2.0)

Lung cancer consistently linked to PM2.5 in ACS CPS-II

Lung Cancer Attributable to $PM_{2.5}$

Environmental Research 120 (2013) 33–42

Contents lists available at SciVerse ScienceDirect

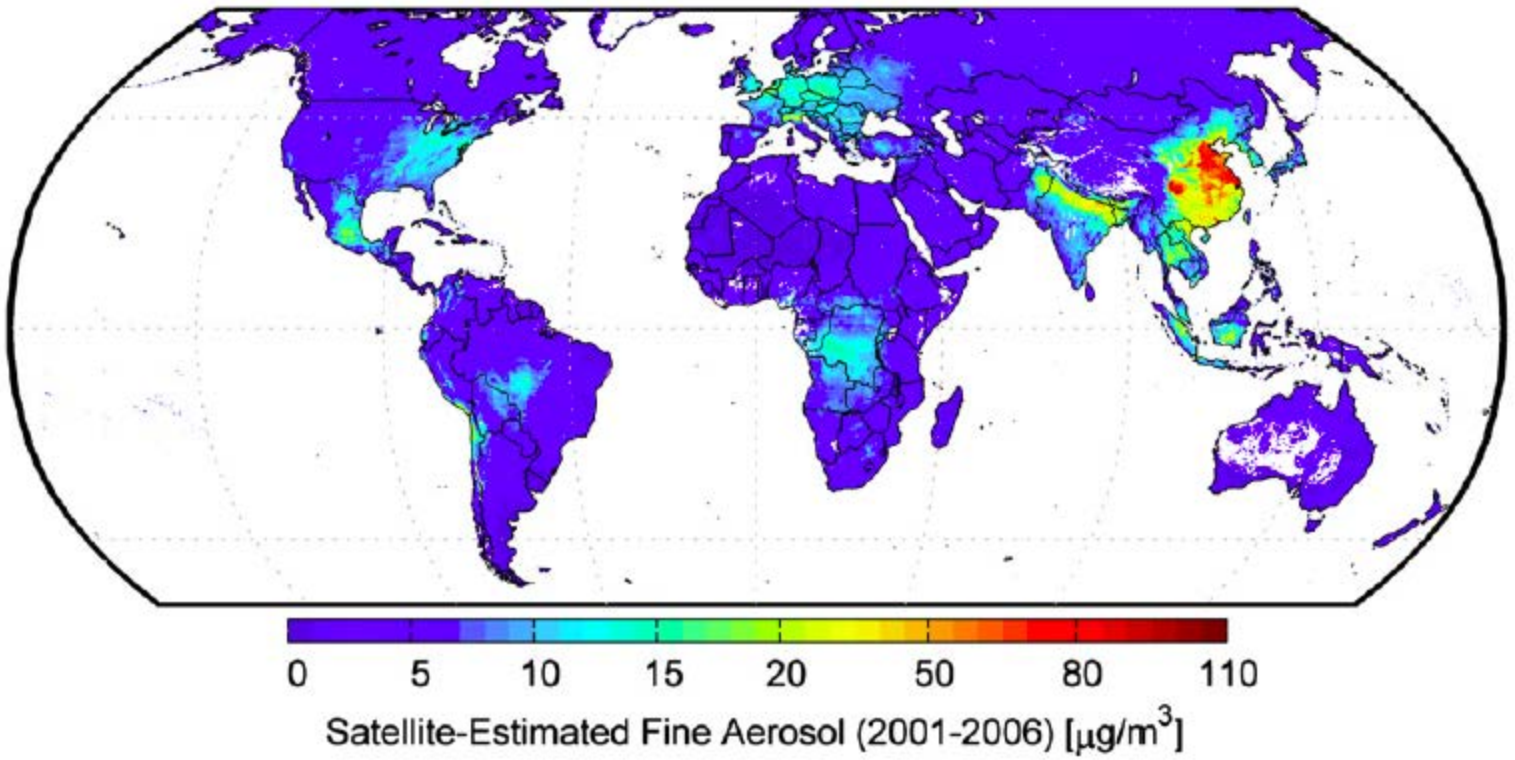
Environmental Research

journal homepage: www.elsevier.com/locate/envres

Estimates of global mortality attributable to particulate air pollution using satellite imagery

Jessica Evans [a,*], Aaron van Donkelaar [b], Randall V. Martin [b,c], Richard Burnett [d], Daniel G. Rainham [e], Nicholas J. Birkett [f], Daniel Krewski [f]

Satellite Mapping of Global Tropospheric PM2.5 Concentrations



12.8 % (5.9 – 18.5%) of lung cancer attributable to $PM_{2.5}$

Occupational Lung Cancer Risks

Lung Cancer Risks by Occupation

Journal of Toxicology and Environmental Health, Part A, 72: 658–675, 2009

ISSN: 1528-7394 print / 1087-2620 online
DOI: 10.1080/15287390802476892

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Occupations and Lung Cancer: A Population-Based Case-Control Study in British Columbia

Nagarajkumar Yenugadhati[1,2], Nicholas J. Birkett[2], Franco Momoli[1], and Daniel Krewski[1]

[1]*R.Samuel McLaughlin Centre for Population Health Risk Assessment, University of Ottawa, 1 Stewart Street, Ottawa, Ontario, and* [2]*Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ontario*

Lifetime occupational histories collected on 14,755 incident lung cancer cases, including 2,998 lung cancer cases in British Columbia from 1983 - 1990

Number of Occupations and Sample Size

TABLE 3

Effective Sample Size for the Analysis of the Association Between Occupations and Lung Cancer

Type of lung cancer	Occupations[a]	Cases	Controls	Total
All types	276/551	2671	7074	9745
Squamous-cell carcinoma	179/549	928	7074	8002
Adenocarcinoma	165/541	824	7074	7898
Small-cell carcinoma	116/542	490	7074	7564
Large-cell carcinoma	87/526	315	7074	7389

[a]Usual occupations having at least three cases and three controls/all occupations represented in the data.

Main Findings

- Excess risk of lung cancer for all histological subtypes combined found for:
  - Workers in metal processing: OR=2.54 (1.39-4.64)
  - Workers in metal machining: OR=1.88 (1.17-3.00)
  - Bakers: OR=2.72 (1.13-6.55)
  - Ship deck crew: OR=2.42 (1.02-5.75)

- Excess risk of lung cancer for specific histological subtypes found for:
  - Construction workers: Squamous cell OR= 1.39 (1.11-1.73)
  - Insulators, construction: Adenocarcinoma OR=4.60 (1.15-18.35)
  - Electricians, construction: Small cell OR=3.43 (1.34-8.77)
  - Chefs and cooks: Large cell OR=2.95 (1.08-8.10)
  - Medical/ health workers: Large cell: OR=2.45 (1.10-5.47)

Specific Occupational Exposures

Specific Occupational Exposures and Lung Cancer Risk

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 34:144–156 (1998)

Associations Between Several Sites of Cancer and Occupational Exposure to Benzene, Toluene, Xylene, and Styrene: Results of a Case-Control Study in Montreal

Michel Gérin, PhD,[1*] Jack Siemiatycki, PhD,[2,3] Marie Désy, MSc,[2] and Daniel Krewski, PhD[4,5]

Job histories for 3,730 cancer patients (15 types of cancers) and 533 population controls translated into occupational exposures, including benzene, toluene, xylene, and styrene

TABLE V. Odds Ratios Between Exposure to Four Aromatic Hydrocarbons and 15 Types of Cancer by Exposure Level, Using Pooled Controls, Montreal, 1979–1986

Cancer site/substance	Exposure level[a]	No. of controls	No. of cases	Odds ratio[b]	95% Confidence interval[c]
Lung					
Benzene	Unexposed	854	683	1.0	na
	Low	150	127	1.1	0.8–1.5
	Medium	43	34	0.8	0.5–1.3
	High	19	13	0.7	0.3–1.7
Toluene	Unexposed	895	728	1.0	na
	Low	121	92	0.9	0.7–1.3
	Medium	37	25	0.7	0.4–1.2
	High	13	12	1.1	0.5–2.7
Xylene	Unexposed	927	748	1.0	na
	Low	104	81	0.9	0.7–1.3
	Medium	23	12	0.7	0.3–1.5
	High	12	16	1.6	0.7–3.8
Styrene	Unexposed	1039	847	1.0	na
	Low	19	5	0.3	0.1–0.9
	Medium/high	8	5	0.9	0.2–3.3

No clear association between occupational exposure to BTXS and lung cancer in this study

Causes of Human Lung Cancer

Agent	Attributable Fraction	Reference(s)
Tobacco smoking	70-90%	ALS (2013); Parkin et al. (2011); WHO (2013)
Residential radon	3–14%	Brand et al. (2005); Menzler et al. (2008); WHO (2013)
Particulate air pollution	5-13%	Evans et al. (2013); Veneis et al. (2007); WHO (2013)
Diesel emissions	6%	Vermeulen et al. (2013)
Other occupational exposures	3-15%	ALS (2013); Parkin et al. (2011)
Environmental tobacco smoke	3%	ALS (2013)
Radiation	<1%	Parkin et al. (2011)
Solvents	<<1%?	Vizcaya et al. (2013)