Lung cancer, smoking (not), and radon: Public health policy for Canada

CDC

BC Centre for Disease Control
An agency of the Provincial Health Services Authority

National Collaborating Centre for Environmental Health
Centre de collaboration nationale en santé environnementale

Commons Standing Committee on Health 18 June 2015

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Percent distribution of new and fatal cancer cases by sex: Canada 2014 (estimated) Chronic Disease Surveillance and Monitoring Division, CCDP, Public Health Agency of Canada

Males 97,700 New cases

Prostate	24.1%
Colorectal	13.9%
Lung	13.7%
Bladder	6.1%
Non-Hodgkin lymphoma	4.5%
Kidney	3.9%
Melanoma	3.6%
Leukemia	3.4%
Oral	2.9%
Pancreas	2.4%
Stomach	2.1%
Brain/CNS	1.7%
Liver	1.6%
Esophagus	1.6%
Multiple myeloma	1.5%
Thyroid	1.4%
Testis	1.0%
Larynx	0.9%
Hodgkin lymphoma	0.6%
Breast	0.2%
All other cancers	8.8%

Females 93,600 New cases

Breast	26.1%
Lung	13.3%
Colorectal	11.6%
Body of uterus	6.4%
Thyroid	4.9%
Non-Hodgkin lymphoma	3.9%
Melanoma	3.2%
Ovary	2.9%
Leukemia	2.7%
Pancreas	2.5%
Kidney	2.4%
Bladder	2.1%
Cervix	1.6%
Oral	1.5%
Brain/CNS	1.3%
Stomach	1.3%
Multiple myeloma	1.2%
Liver	0.6%
Esophagus	0.5%
Hodgkin lymphoma	0.5%
Larynx	0.2%
All other cancers	9.1%

Males 40,000 Deaths

Lung	27.0%
Colorectal	12.8%
Prostate	10.0%
Pancreas	5.5%
Bladder	3.9%
Esophagus	3.9%
Leukemia	3.8%
Non-Hodgkin lymphoma	3.6%
Stomach	3.2%
Brain/CNS	2.9%
Kidney	2.8%
Liver	2.0%
Oral	2.0%
Multiple myeloma	1.9%
Melanoma	1.6%
Larynx	0.8%
Breast	0.2%
All other cancers	12.2%

Females 36,600 Deaths

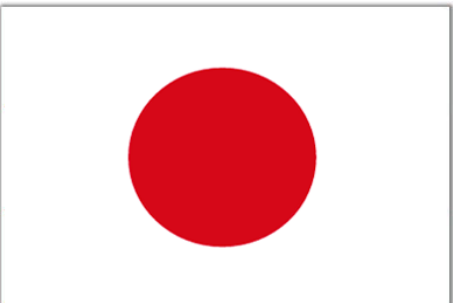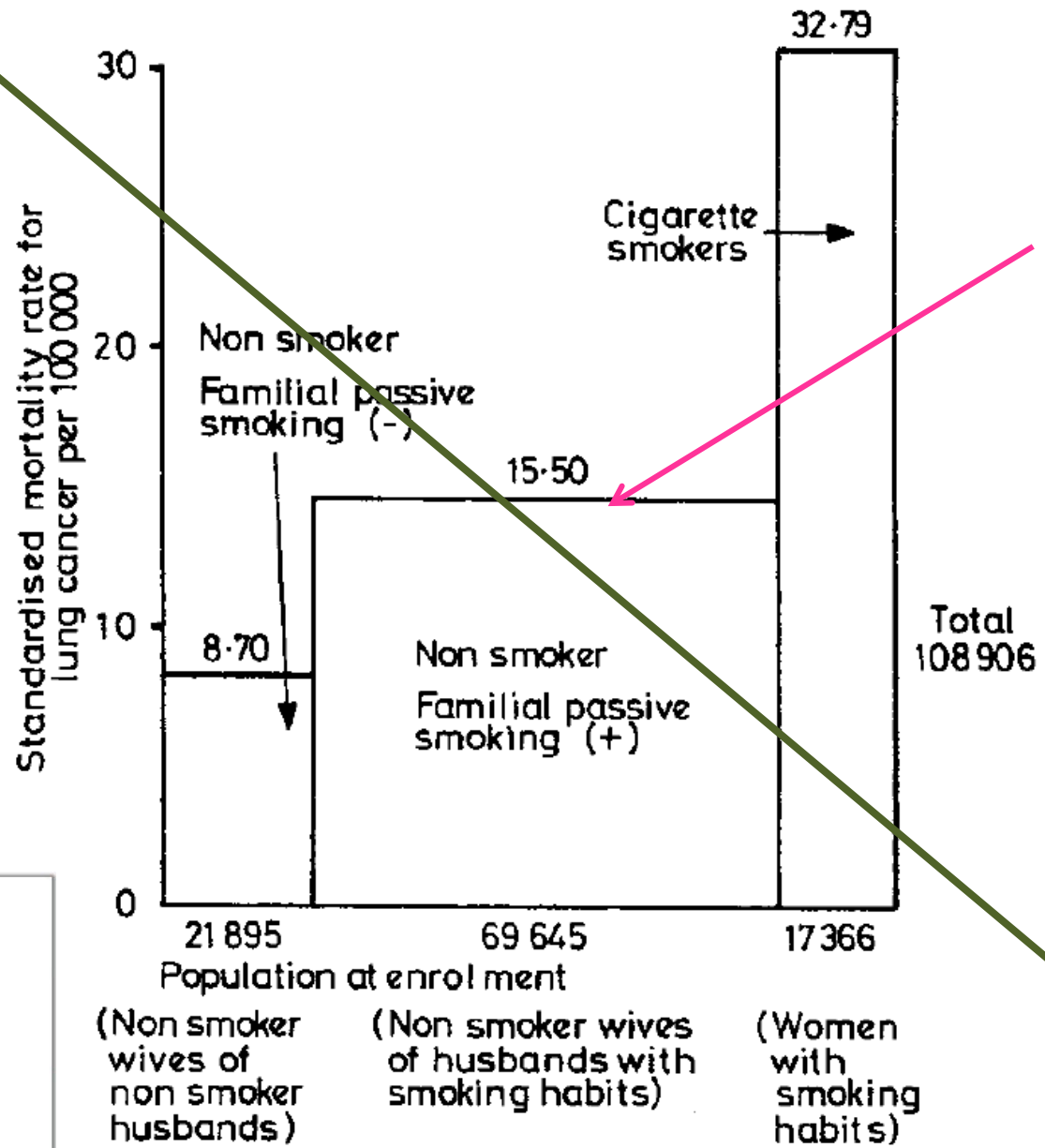|	
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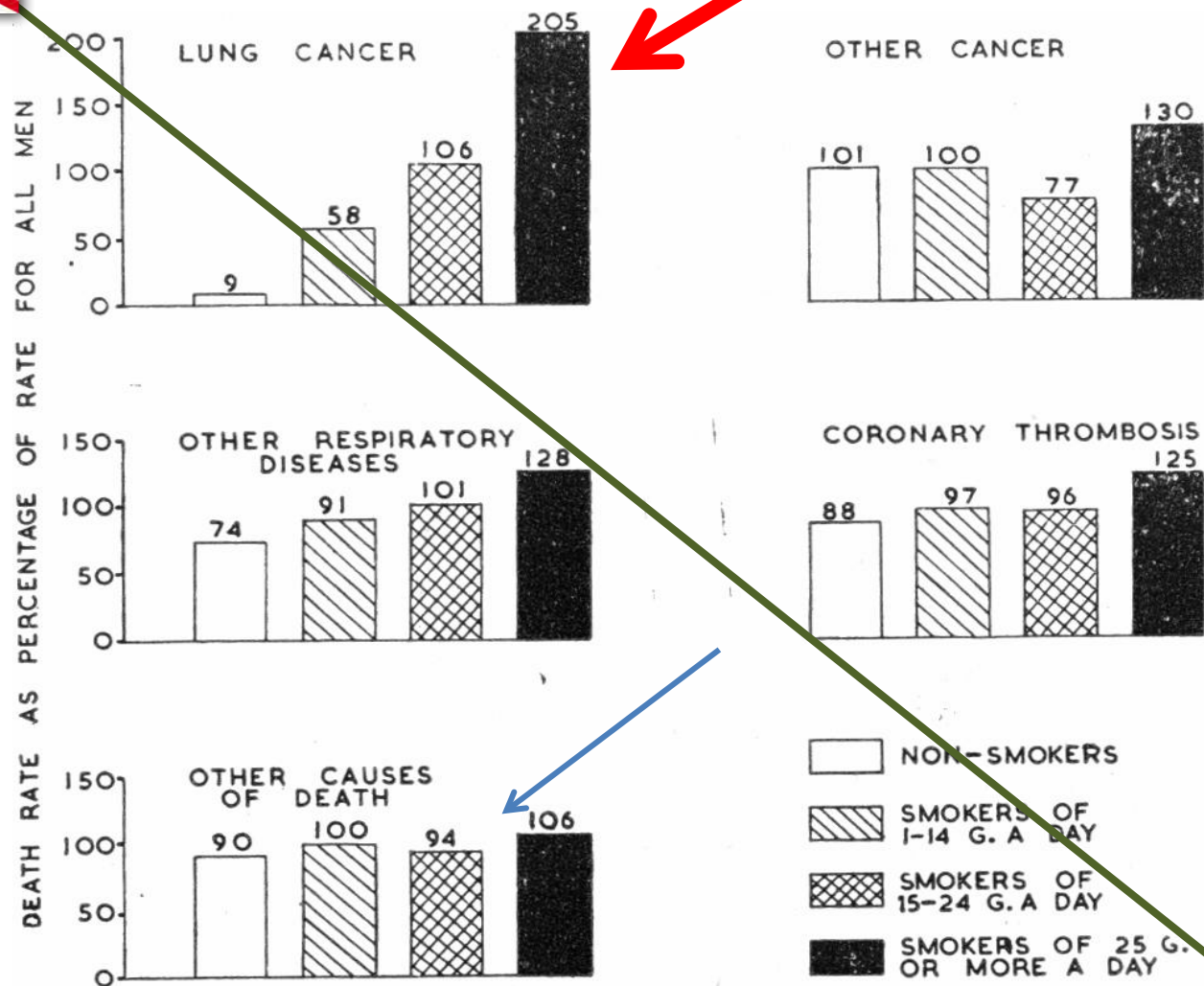
LUNG CANCER AND OTHER CAUSES OF DEATH IN RELATION TO SMOKING: A SECOND REPORT ON THE MORTALITY OF BRITISH DOCTORS BY RICHARD DOLL, M.D., M.R.C.P., A. BRADFORD HILL, C.B.E., F.R.S.
British Medical Journal, 1956

Lung cancer mortality in women according to the presence or absence of direct and familial indirect smoking (Hirayama, 1981)

Lung cancer in life-long non-smokers*

(*<100 lifetime cigarettes)

	Smokers	Never-Smokers
Time trend	stable (Canada)	apparently rising
Geography		Asia+++
Sex		female predominance
Age		younger at diagnosis
Cell type (s)	squamous, adeno-	fewer squamous, also more mixed and carcinoid, few small cells
Genetics		defective DNA repair
Symptoms at diagnosis		higher %
5 year survival	56%	64%

Principal risk factors (excluding occupational exposure) for lung cancer occurrence and corresponding estimated risks (Couraud, 2012)

Risk factor	Estimated risk (95% confidence interval)	Population	Ref.
Family history	OR = 1.40 (1.17–1.68)	Never smokers (meta-analysis)	147
Use of menopausal hormone replacement therapy	OR = 1.76 (1.072–2.898)	Women, never-smokers, adenocarcinoma, (meta-analysis)	57
Environmental tobacco smoke	OR = 1.26 (1.07–1.47)	Never smokers (meta-analysis)	32
Domestic radon exposure	10.6% (0.3–28.0) per increase of 100 Bq/m^3	Never smokers (meta-analysis)	61
Air pollution – increase of 10 µg/m^3 in PM$_{2.5}$	HR = 1.24 (1.12–1.37)	General population	66
Air pollution – increase of 10 ppb in SO$_2$	HR = 1.26 (1.07–1.48)	General population	66
Air pollution – increase of 10 ppb in NO$_2$	HR = 1.17 (1.10–1.26)	General population	66
Cooking oil fumes	OR = 2.12 (1.81–2.47)	Women, never smokers, Chinese (meta-analysis)	67
Smoke from domestic combustion for heating and cooking	OR = 1.22 (1.04–1.44)	General population, Europe	70
Patient history of tuberculosis	RR = 1.90 (1.45–2.50)	Never smokers (meta-analysis)	81
Patient history of COPD/emphysema/chronic bronchitis	RR = 1.22 (0.97–1.53)	Never smokers (meta-analysis)	81
Patient history of parenchymal infection	RR = 1.36 (1.10–1.69)	Never smokers (meta-analysis)	81
Low socioeconomic status	RR = 1.65 (1.19–2.28)	General population (meta-analysis)	78
High intake of fruit	OR = 0.60 (0.46–0.7)	General population but higher in current smokers	85

OR = Odds ratio, HR = Hazard ratio, RR = Relative Risk, COPD = Chronic Obstructive Pulmonary Disease.

Estimated Attributable Portion of Lung Cancer Cases by Cause [11]

*

100%	
80%	90%
60%	
40%	
20%	
0%	9-15% 10% 1-2%

Estimated Percent of Cases Attributable to Cause

Active Smoking   Radon   Occupational Carcinogen Exposure   Outdoor Air Pollution
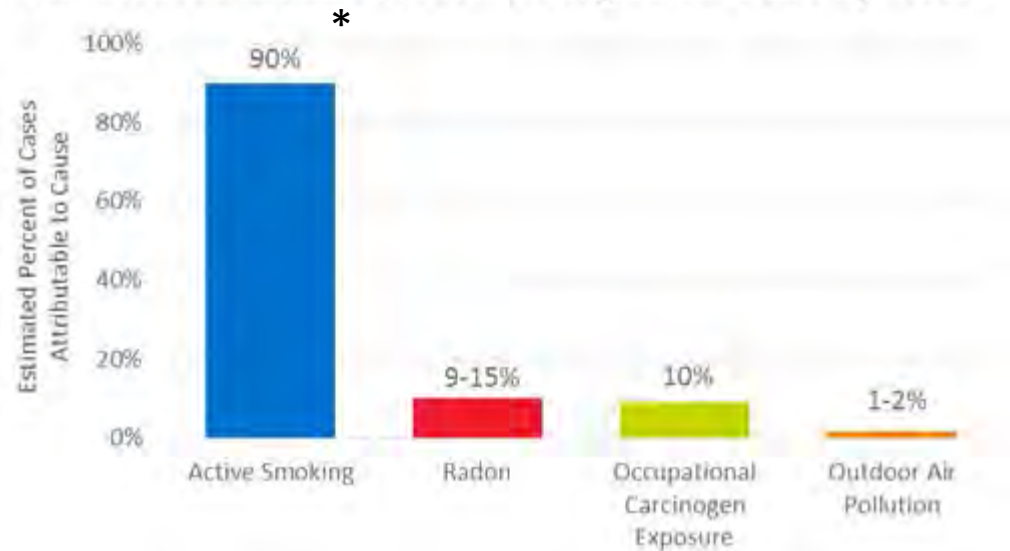
American Lung Association – Lung cancer fact sheet, 2015

*   % total >100

The mortality burden of radon-related lung cancer

SEER Estimated 2010 US Mortality for Selected Cancers

Types of cancer:
- LEUKEMIA — 21,840
- LYMPHOMA — 21,530
- LUNG CANCER (RADON) — 21,000
- LIVER & INTRA-HEPATIC BILE DUCT — 18,910
- ESOPHAGUS — 14,500
- OVARY — 13,850
- BRAIN/NERVOUS SYSTEM — 13,140
- KIDNEY & RENAL PELVIS — 13,040
- CERVIX — 12,200
- STOMACH — 10,570
- MELANOMA — 8,700
- ORAL/PHARYNX — 7,880
- LARYNX — 3,600
- THYROID — 1,690
- BONE/JOINT — 1,460

# of annual deaths
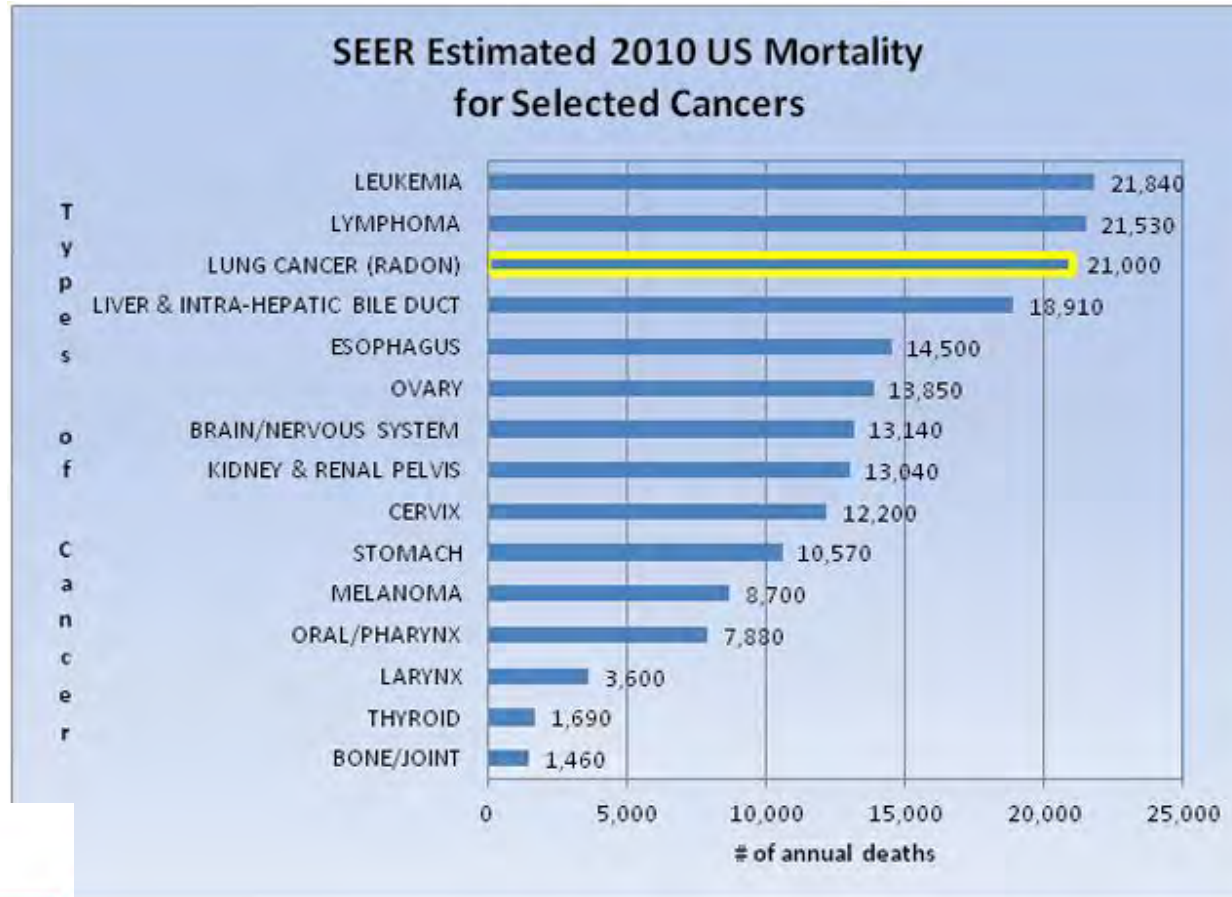
http://seer.cancer.gov/csr/1975_2007/results_single/sect_01_table.01.pdf

Any radon is bad news

Lung cancer risk (relative to no radon) is calculated on the basis of life-long radon exposure

Relative risk of lung cancer increases ~16% for every 100 Bq/m³ of life-long radon exposure

100 Bq/m³ = one hundred particles of alpha radiation emitted *every second* per cubic metre of air

WHO handbook on indoor Radon, 2009
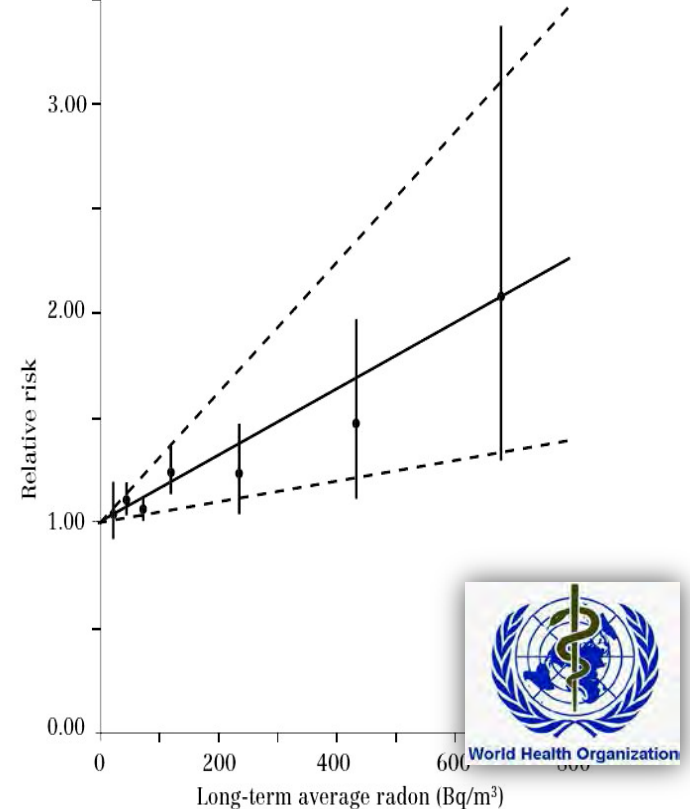
Source: Darby et al. 2005
Relative risks and 95% confidence intervals are shown for categorical analyses and also best fitting straight line. Risks are relative to that at 0 Bq/m³.

Figure 1. Relative risk of lung cancer versus long-term average residential radon concentration in the European pooling study

Most radon-associated lung cancers occur in smokers

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Radon Risk If You Smoke

Radon Level Bq/m³	If 1,000 people who smoked were exposed to this level over a lifetime*	The risk of cancer from radon exposure compares to**
750	About 270 people would get radon-related lung cancer	250 times the risk of drowning
500	About 190 would get radon-related lung cancer	250 times the risk of dying in a home fire
200	About 90 would get radon-related lung cancer	22 times the risk of dying in a fall
100	About 42 would get radon-related lung cancer	8 times the risk of dying in a car crash
50	About 21 would get radon-related lung cancer	Average indoor radon level
20	About 5 would get radon-related lung cancer	Average outdoor radon level

Notes: If you are a former smoker, your risk may be lower.
Bq/m³ = disintegrations/second/cubic meter
* Lifetime risk of lung cancer deaths from US EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003).
** Comparison data calculated using the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Reports.

Radon Risk If You Never Smoked

Radon Level Bq/m³	If 1,000 people who never smoked were exposed to this level over a lifetime*	The risk of cancer from radon exposure compares to**
750	About 36 people would get radon-related lung cancer	35 times the risk of drowning
500	About 24 would get radon-related lung cancer	25 times the risk of dying in a home fire
200	About 10 would get radon-related lung cancer	3 times the risk of dying in a fall
100	About 5 would get radon-related lung cancer	the risk of dying in a car crash
50	About 2 would get radon-related lung cancer	Average indoor radon level
20	- -	Average outdoor radon level

Notes: If you are a former smoker, your risk may be higher.
Bq/m³ = disintegrations/second/cubic meter
* Lifetime risk of lung cancer deaths fromUS EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003).
** Comparison data calculated using the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Reports.

Table 2 | Numbers of deaths from lung cancer in United Kingdom, 2006, by cause

Cause	No (%) of deaths from lung cancer	Deaths from lung cancer		
Not active smoking or indoor radon	4664* (13.6)			
Radon but not active smoking	157† (0.5)			
Active smoking and radon‡:		3.3% due to radon§	85.9% due to active smoking	86.4% due to active smoking or radon
Current smokers	532 (1.6)			
Former smokers	421 (1.2)			
Active smoking but not indoor radon	28 376 (83.1)			
Total No of lung cancer deaths¶	34 150 (100)			

*Including any deaths caused by passive smoking but not by radon.
†Including any deaths caused by passive smoking and radon.
‡Cancers that would have been avoided by avoidance of either indoor radon or smoking.
§Mean indoor concentration of radon in UK is 21 Bq/m^3.
¶Total number of deaths from all causes in UK in 2006 was 572 224. Indoor radon is estimated to cause 1110 (that is, 157+532+421) deaths (1 in 516 or 0.2% of deaths from all causes in UK).

Gray, BMJ, 2009

Smoking/radon synergy: consequences

Radon and Smoking are considered to be synergistic on lung cancer occurrence, their joint risk being more than additive, but less than multiplicative.

As a result, as smoking rates decline, the rate of (radon + smoking) -related lung cancers will decline proportionally more.

Further, all radon-related cancers (of whom most now are in smokers) will decline proportionally more than the drop in smoking prevalence.

As a proportion of all lung cancers, the proportion of radon-related lung cancers in non-smokers will rise.

Lantz et al (A J Pub Hlth, 2013): Reducing smoking in the population is the most cost-effective strategy for reducing the public health burden of radon.

The Canadian Public Health stance on radon

Pre-2007

---a private affair

- Guideline was 800 Bq/m^3
- Large-scale testing
- Offered advice, when asked
- Lobbied for a lower guideline

Following the revised 200 Bq/m^3 radon guideline

- Promote the guideline
- Encourage test and remediate

- Build remediator capacity
- Promote radon measures in the National Building Code

Canada's 200 Bq/m³ guideline, at best, offers little population protection
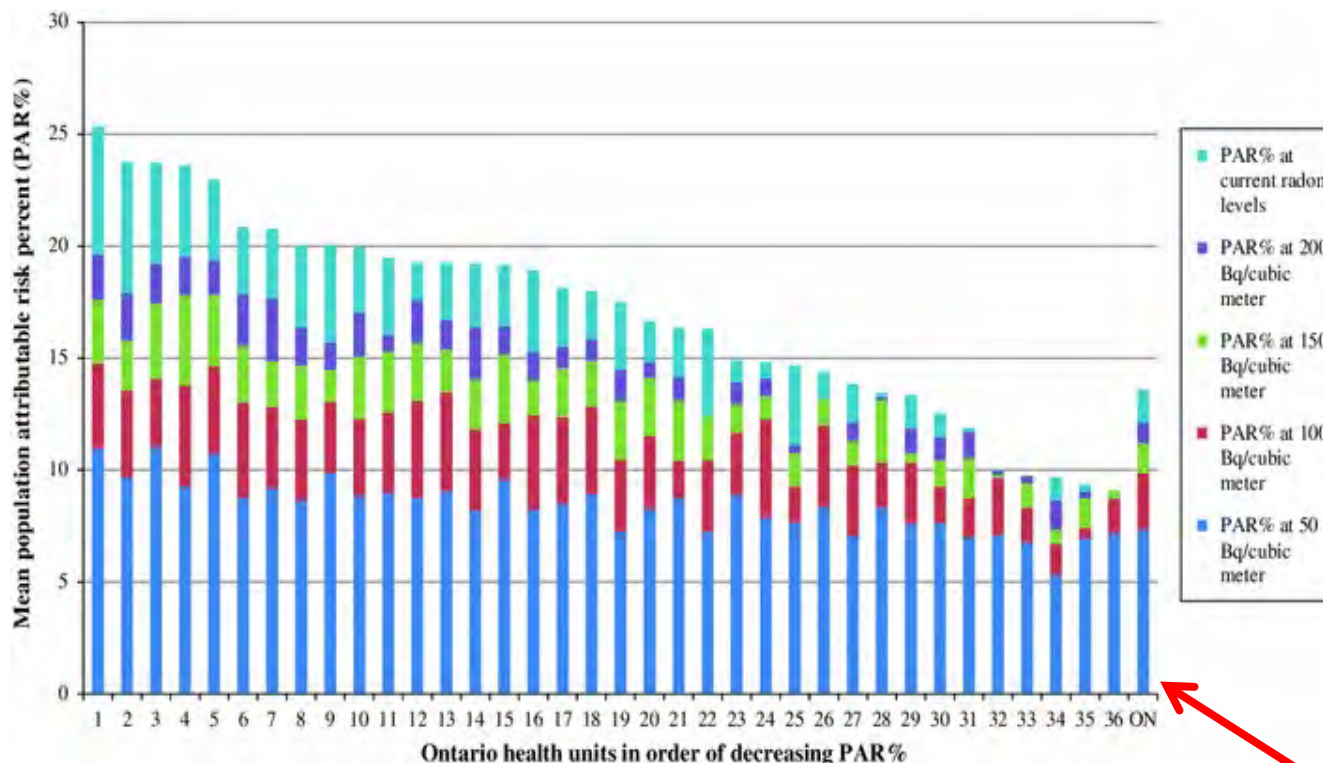
= 13% of all Ontario lung cancer deaths

because any radon is bad news

In Ontario, if all homes with >200 Bq/m³ were remediated to outdoor radon levels,
91 deaths/year (11% of all radon-related 2007 deaths) could be averted, versus 871 deaths
if all homes were made low radon---Peterson 2013

Netherlands: Indoor radon levels have risen over time

Lembrechts, Sci Tot Env, 2001
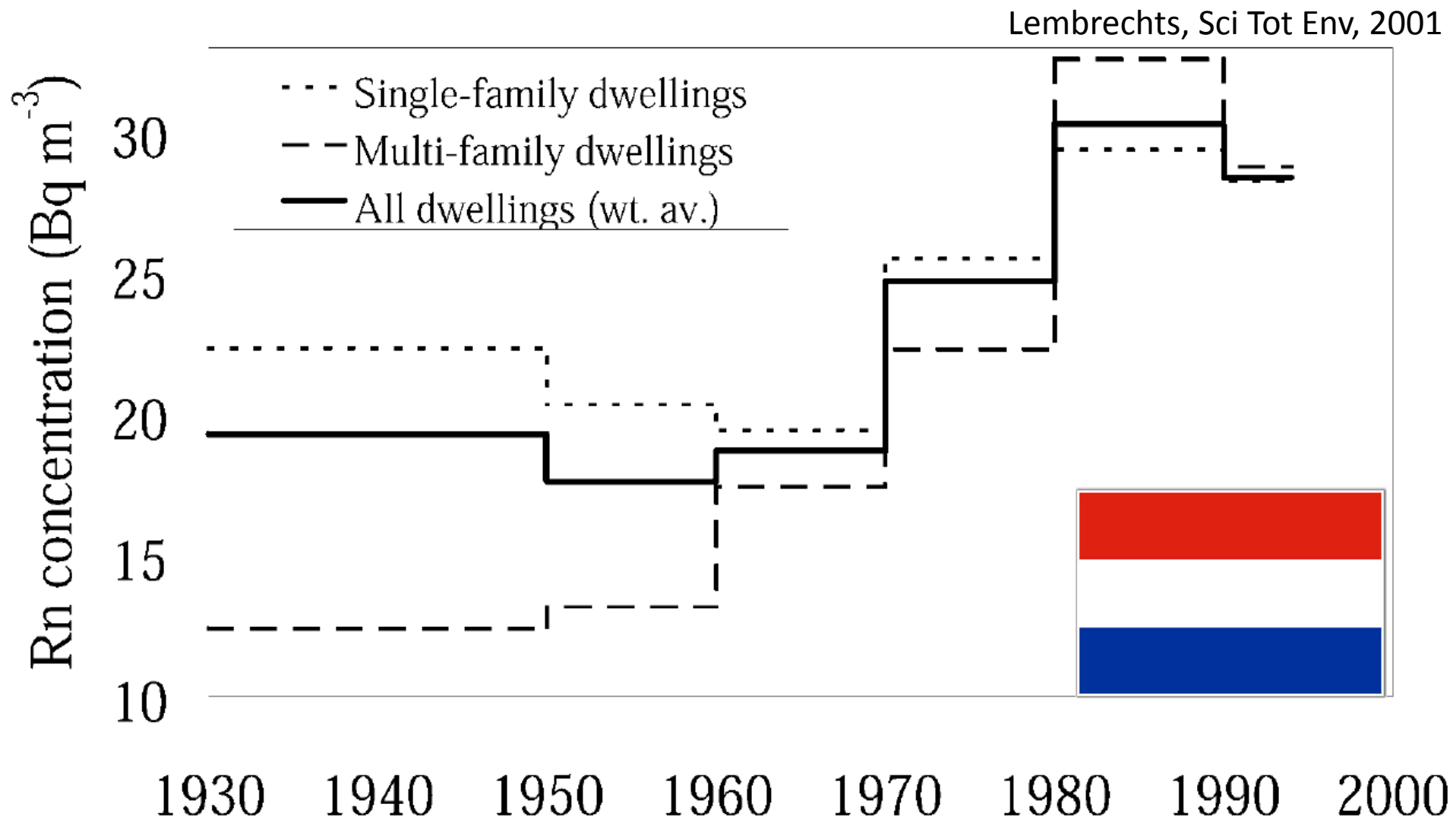
So, even if all Canadians tested and those whose homes (day cares, schools and workplaces) tested over 200 Bq/m³ remediated, most Canadians would continue to live (sleep, work and learn) in environments well above outdoor radon levels and most cases of radon-related lung cancer would not be averted.

And, while Canadians are increasingly aware of radon, few test for it in their homes, and most whose homes test over 200 Bq/m³ do not remediate.

For efficacy, acceptability, sustainability…..

with universal active radon removal

Gray, BMJ, 2009

New homes

£20 000-£30 000 per QALY gained range

Cost per QALY gained (£ 000s)

| Cost of installing membrane or other measures (£50 to £250) | Radon reduction from membrane or other measures (20-80%) | Lung cancer treatment costs (£7000-£18 000) | Annual NHS costs of added life expectancy (omitted to £12 500) | QALYs gained per lung cancer case (7-13 years) | Increase in lung cancer risk per 100 Bq/m³ increase (5-31%) | Latency period for lung cancer risk reduction (0-20 years) | Discount rate (3.5/0 and 6/6%) |

Existing homes

Cost per QALY gained (£ 000s)

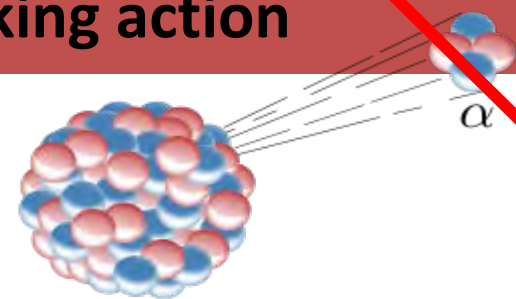| Test invitation acceptance rate (10-60%) | Remediation rate (12-50%) | Remediation effectiveness (70-95%) | Unit cost of invitations (50p-£6) | Unit cost of testing (£20-£75) | Lung cancer treatment costs (£7000-£18 000) | Annual NHS costs of added life expectancy (omitted to £12 500) | QALYs gained per lung cancer case (7-13 years) | Increase in lung cancer risk per 100 Bq/m³ increase (5-31%) | Latency period for lung cancer risk reduction (0-20 years) | Discount rate (3.5/0 and 6/6%) |

Towards an effective Canadian policy stance on Radon

Current dominant policy direction

- **Encourage test and remediate**

- Build remediator capacity

- *(promote new construction/building codes)*

- *(encourage, partner on research)*

Next steps…
- **Adopt a population approach**
- **Question the current 200 Bq/m³ (or any non-lowest radon possible) guideline**
- **Legislate a radon-resilient building stock (build radon out)**
- **Use provincial authorities (daycares, schools, workplaces)**
- **Integrate radon lowering into anti-smoking action**

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