Riesgos vinculados a la exposición al radón

19ª Jornada de la Sociedad Española de Sanidad Ambiental
GRANADA, 15-abril-2010

Xoán Miguel Barros Dios
Prof. Titular de Medicina Preventiva e Saúde Pública
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA (USC)
Facultativo Especialista de Área del Servicio de Medicina Preventiva y Salud Pública
COMPLEXO HOSPITALAR UNIVERSITÁRIO DE SANTIAGO (CHUS)
Director del Laboratorio de Radón de Galicia (USC)
www.usc.es/radongal

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

Evolución del conocimiento sobre el radón y la salud

1500- Agrícola observa mayor mortalidad por una enfermedad respiratoria en la minas de Erz (Este de Europa).

1879- Karting y Hesse identifican como cáncer pulmonar aquella enfermedad respiratoria.

1921- Uhling relaciona las emanaciones de radio con el cáncer pulmonar.

Años 70- Publicación de primeros estudios que relacionan la exposición a radón y el cáncer pulmonar en mineros.

1987- La EPA (Environmental Protection Agency) establece los 148 Bq/m^3 como concentración que no debe sobrepasarse y a partir de la que se deben realizar reducción de radón en los domicilios.

1988- BEIR IV (Committee of de Biological Effects on Ionizing Radiations) National Academy of Sciences/National Researc Council: Análisis pormenorizado de los trabajos sobre exposición a radón de mineros y de animales. Asocia evidencias publicadas con la aparición de cáncer pulmonar.

Riesgos vinculados a la exposición al radón

Evolución del conocimiento sobre el radón y la salud

1990 - EURATOM Publicación de normativa europea recomendando no superar los 400 Bq/m^3 en casas ya construídas ni los 200 Bq/m^3 en las de nueva construcción.

Años 90 – Estudios sobre exposición residencial a radón y cáncer pulmonar.

1999 – BEIR VI Actualización del BEIR IV definiendo el radón com segundo factor de riesgo de cáncer pulmonar después del tabaco.

2003 – Publicación en Bull Wld Hlth Org 2003:Meta-análisis de 17 estudios de casos y controles en todo el mundo.

2004/05 – Publicación del estudio colaborativo de 13 investigaciones europeas de C-C (pooling *study*). (Darby et al.*Br Med J*)

2005 – Publicación del pooling study americano (USA-Canadá) (Krewski et al. *Epidemiology*)

2005- Inicio del International Radon Project de la OMS para elaboración de un Handbook o Informe Técnico de recomendaciones para implantar Programas de reducción de radón por los Gobiernos miembros. (Genève, marzo 2005; Genève 2006; München 2007).

2008 – Publicación prevista del pooling study mundial y del Informe técnico de la OMS.

Riesgos vinculados a la exposición al radón

¿Por qué se ignora la evidencia o no se acepta?

- Invisible, inodoro, incoloro
- Naturalmente producido
- Pueden observarse muertes no relacionadas con exposición al radón
- Largo período de latencia
- No hay miedo al peligro
- Los cánceres ocurren de uno en uno.
- Riesgo voluntario (??)
- Ausencia de publicidad – no produce historias sensacionalistas
- No hay refuerzos repetitivos para estimularnos a pensar en el.
- El cáncer de pulmón no ocurre en niños

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

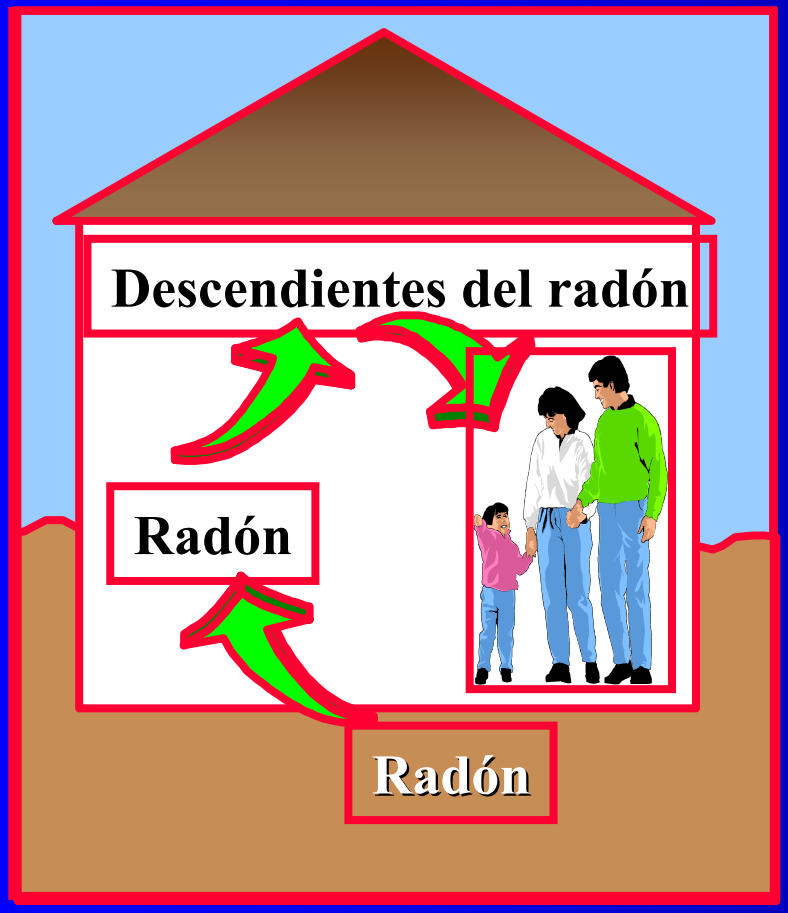
Minas de “radón”

Usos, supuestamente saludables, del aire cargado de radón en las minas, principalmente de uranio.

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

Por qué el radón es un problema?



- La degradación del radón produce partículas alfa radiactivas y otras substancias conocidas como descendientes del radón, que también se degradan produciendo más partículas.
- Esas partículas son fácilmente inhaladas y depositadas en los pulmones donde pueden dañar sensiblemente los tejidos.

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

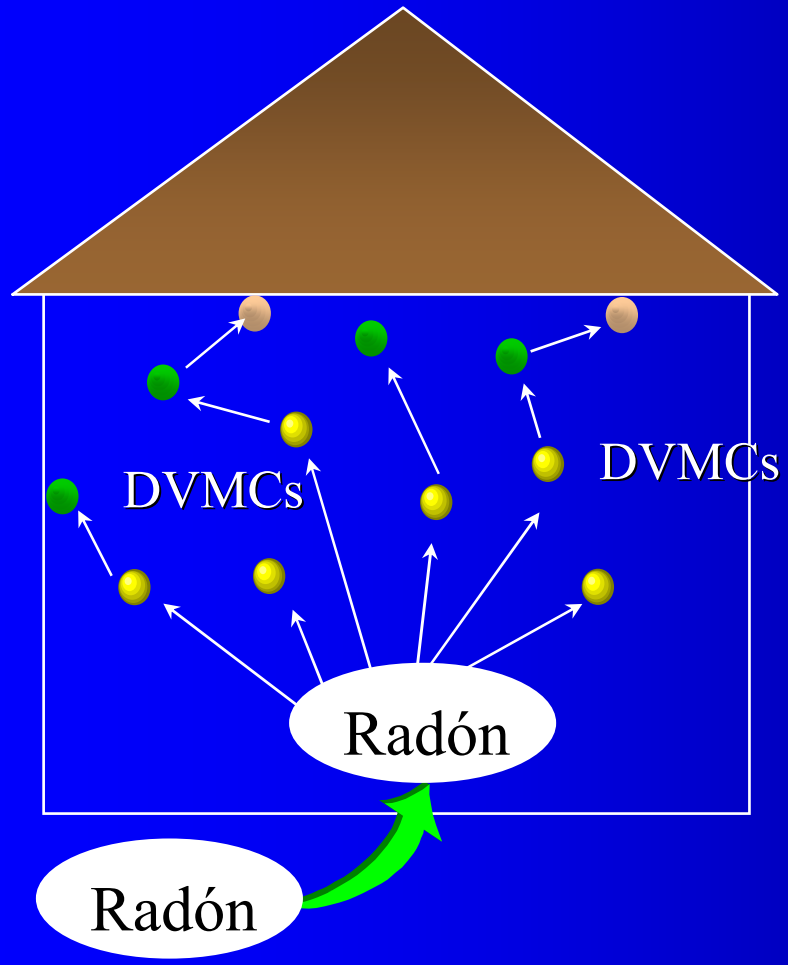
Riesgos vinculados a la exposición al radón

Existe una ubícua exposición a lo largo y ancho de cualquier país en todos los domicilios y lugares de trabajo, de las zonas con suelos potencialmente ricos en uranio-238 y, por tanto, de radio-226, antecesores del Rn-222.

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

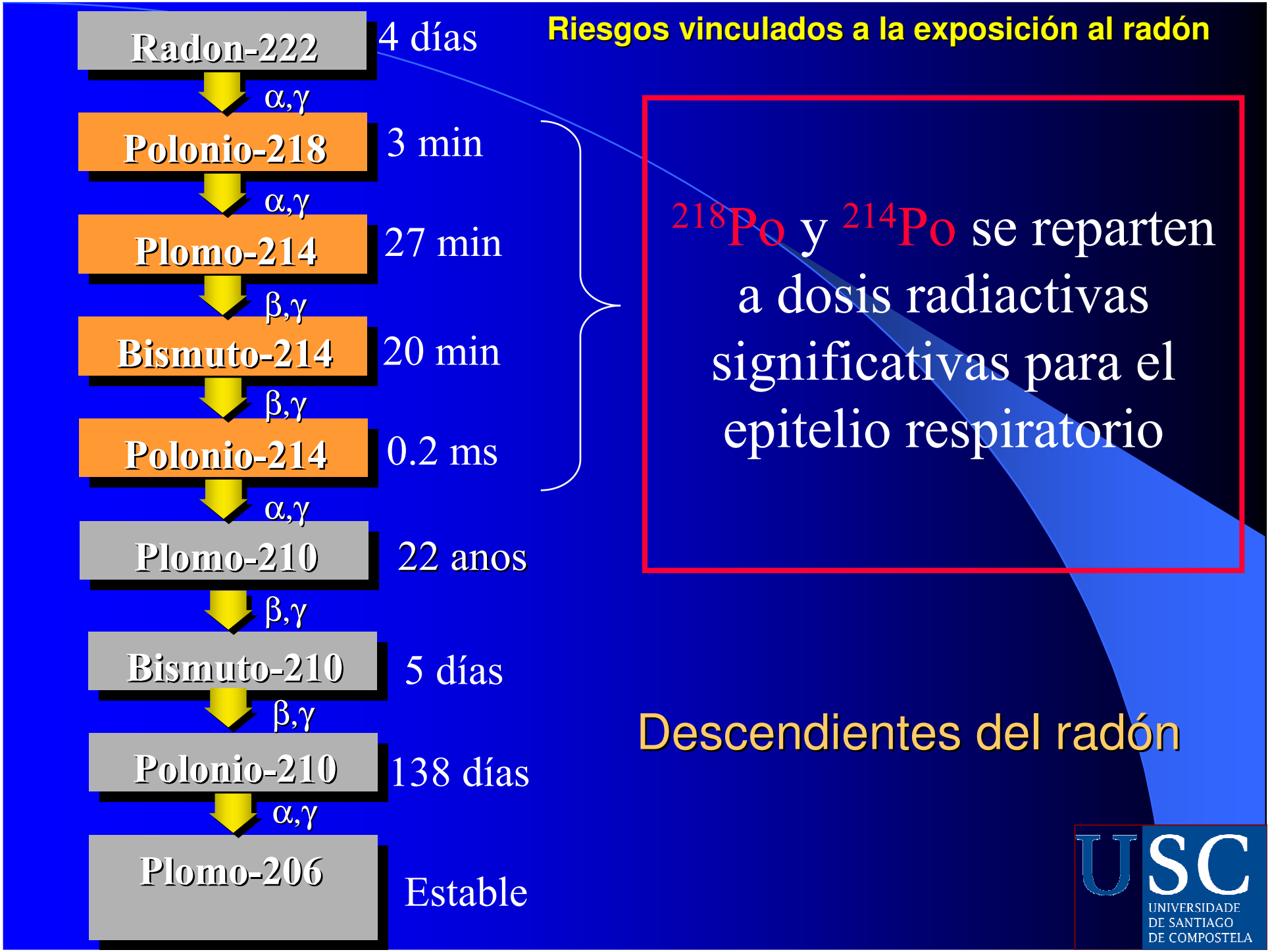
Riesgos vinculados a la exposición al radón

¿Qué ocurre cuando el Rn-222 penetra en una casa?



- El radón entra en la casa.
- El radón se degrada radiactivamente y pasa a otros descendientes de "vida media corta" (DVMC) en el aire, emitiendo partículas alfa.
- Algunos DVMCs permanecen en el aire.
- Algunos DVMCs se fijan sobre superficies.

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA


Riesgos vinculados a la exposición al radón
Radon-222
4 días
α,γ
Polonio-218
3 min
α,γ
Plomo-214
27 min
β,γ
Bismuto-214
20 min
β,γ
Polonio-214
0.2 ms
α,γ
Plomo-210
22 anos
β,γ
Bismuto-210
5 días
β,γ
Polonio-210
138 días
α,γ
Plomo-206
Estable
^{218}Po y ^{214}Po se reparten a dosis radiactivas significativas para el epitelio respiratorio
Descendientes del radón
USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

Table 4-3. Radioactive Properties of ^{222}Rn and Its Short-lived Progeny

Isotope	Historical symbol	Principal radiation(s)	Q-Value of principal decay mode (MeV)	Half-life	Specific activity (Ci/g)
^{222}Rn	Rn	α	5.5903	3.8235 days	1.54×10^{5}
^{218}Po[a]	RaA	α	6.1147	3.098 minutes	2.78×10^{8}
^{218}At	At	α	6.874	1.5 seconds	3.45×10^{18}
^{214}Pb	RaB	β,γ	1.023	26.8 minutes	3.28×10^{4}
^{214}Bi	RaC	β,γ	5.6168	19.9 minutes	4.41×10^{7}
^{214}Po[a]	RaC'	α	7.8335	164.3 μseconds	3.21×10^{14}
^{210}Tl	RaC"	β	5.489	1.30 minutes	6.89×10^{8}

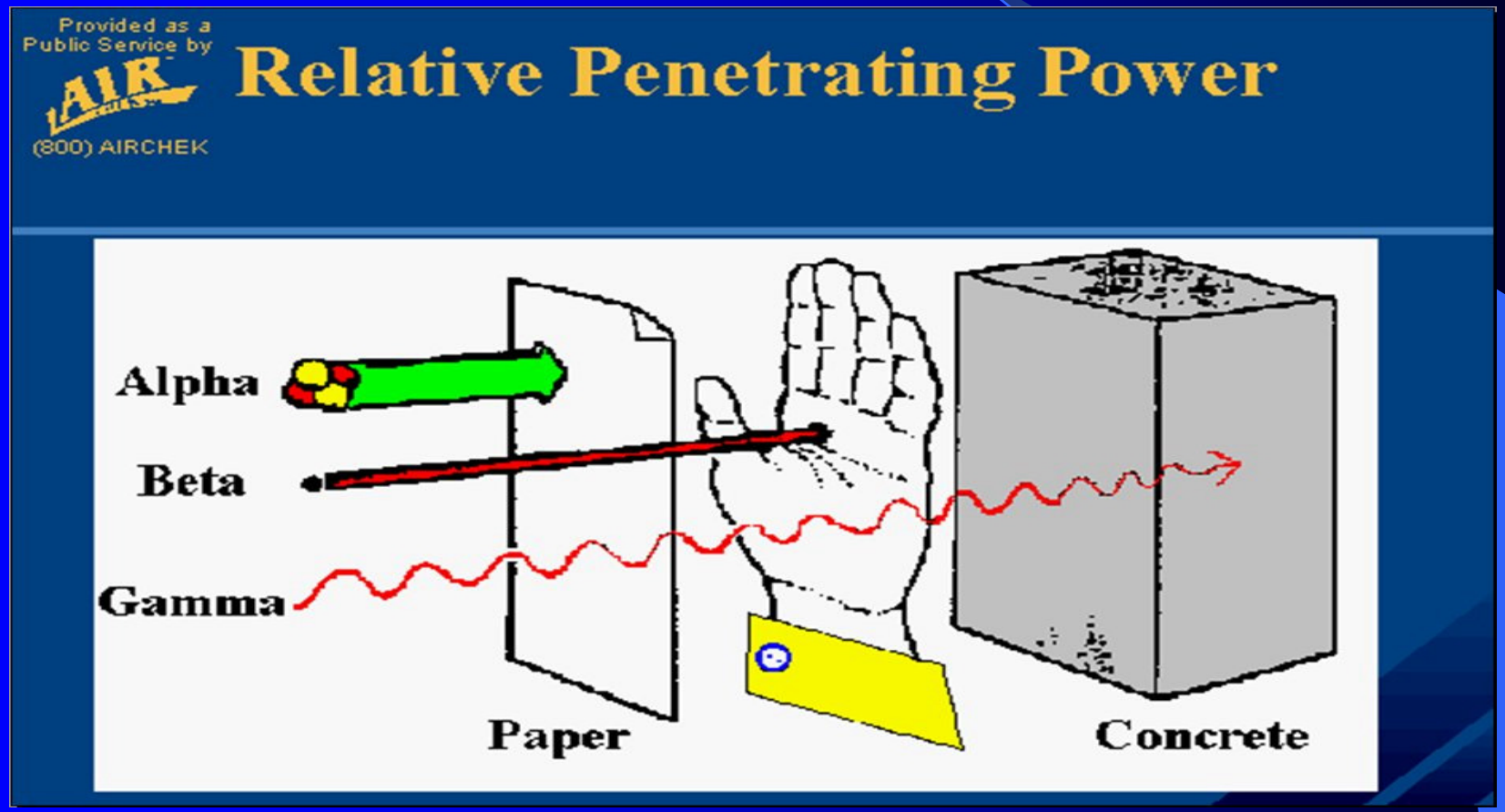
[a]Isotopes of primary radiological interest due to the potential for retention in the lung and subsequent alpha decay.

MeV = million electron volts

Source: DOE 2008

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón



Riesgos vinculados a la exposición al radón

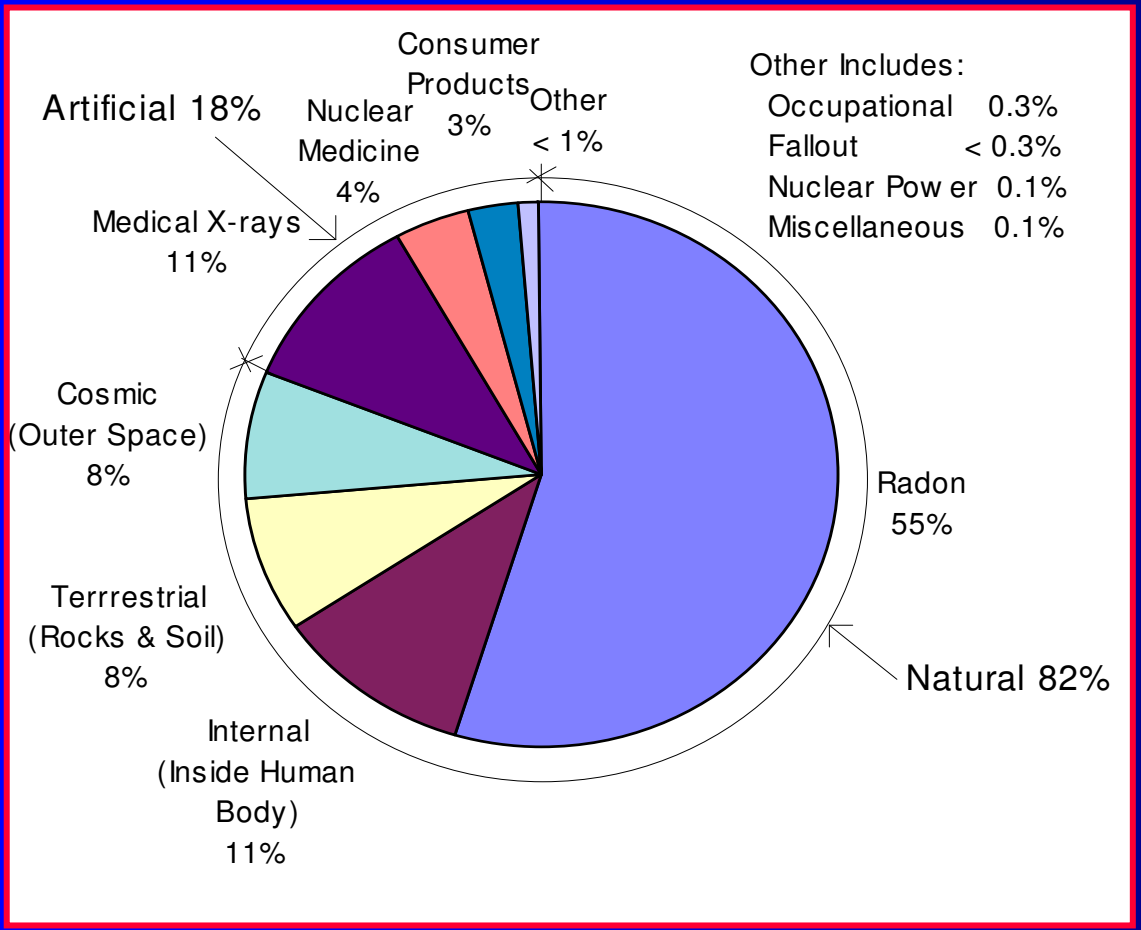
Para el promedio individual en U.S.A. El radón y descendientes significan más del 50% de la dosis de radiación !

Y para un habitante de Iowa representan más del 75%!!

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

Dosis efectiva anual equivalente para un habitante de U.S. NCRP 93 (1987)



Natural	**(mrem)**
Radon	200
Cósmica	27
Terrestre:	
-externa	28
-interna	39
Artificial	**(mrem)**
-Diag. X-rays	39
-Nuc. Med.	14
-Prod consumo	10
-Otros	~1
TOTAL	**~360**

Riesgos vinculados a la exposición al radón

Dosis efectiva media mundial de radiación en 2000, de origen natural y antropogénico (mSv)

(Fuente: UNSCEAR 2000).

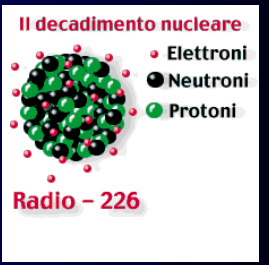
FUENTE DE RADIACIÓN	DOSIS (mSv)
Fondo natural (total, todas las fuentes)	2,4
Inhalación (principalmente radón)	1,2
Rayos gamma terrestres	0,5
Rayos cósmicos	0,4
Ingestión	0,3
Diagnósticos médicos	0,4
"testing" nucleares atmosféricos	0,005
Accidente de Chernobyl	0,002
Producción energía nuclear	0,002

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

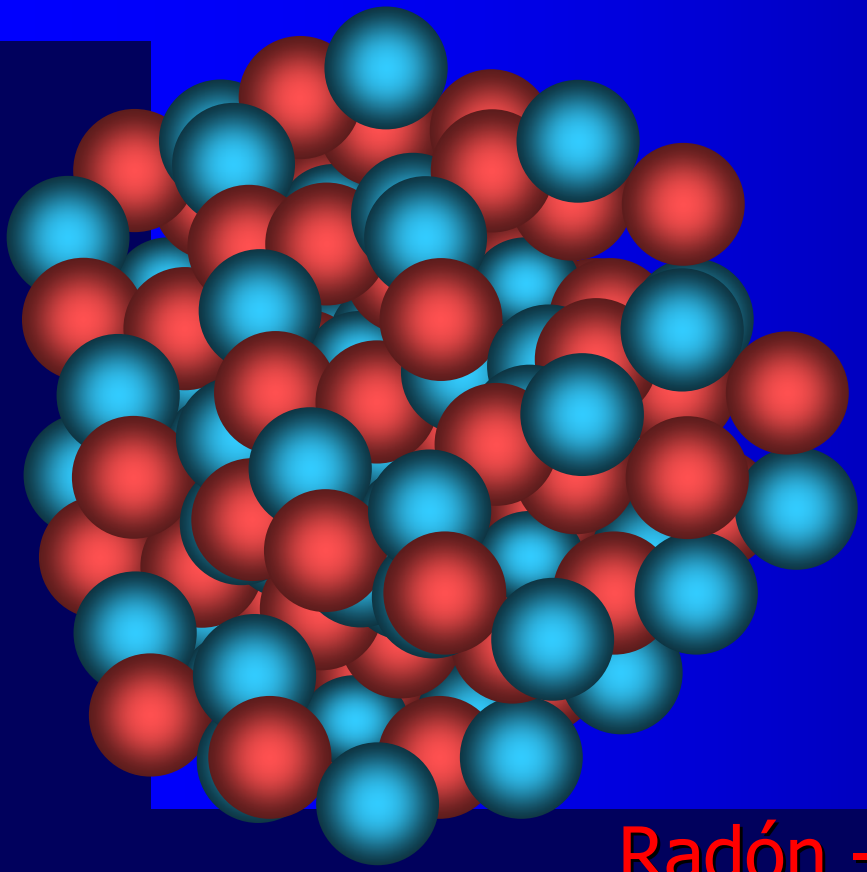
USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

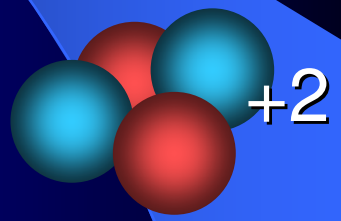
Riesgos vinculados a la exposición al radón

Producción de la radiación alfa (α)



Núcleo de ^{4}He emitido por núcleo ^{222}Rn

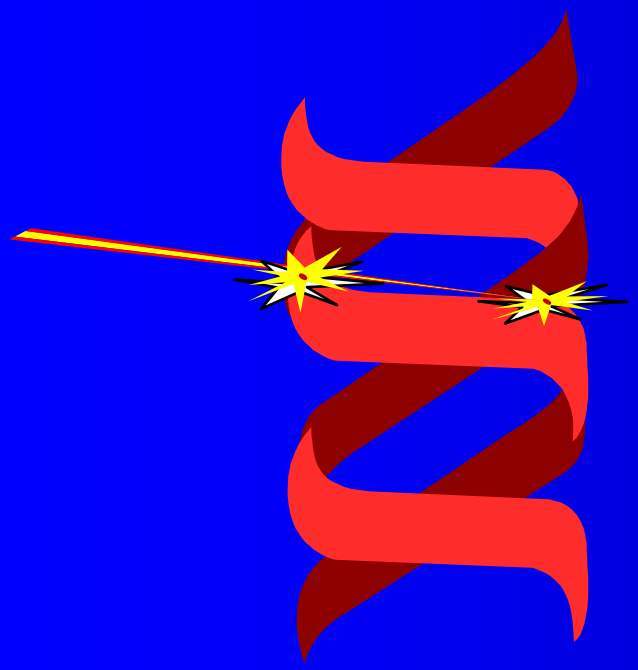




Radón - 222 → $^{4}He + ^{218}Po$

Riesgos vinculados a la exposición al radón

¿Qué ocurre cuando se inhala el radón?



Lesión en la doble hélice

- Partículas altamente radioactivas se adhieren al tejido pulmonar, donde pueden irradiar sensiblemente las células broncopulmonares.

- La radiación puede alterar las células, increntando el riesgo potencial para el cáncer.

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

La radiación ionizante puede dañar directa e indirectamente el DNA

Partícula Alfa

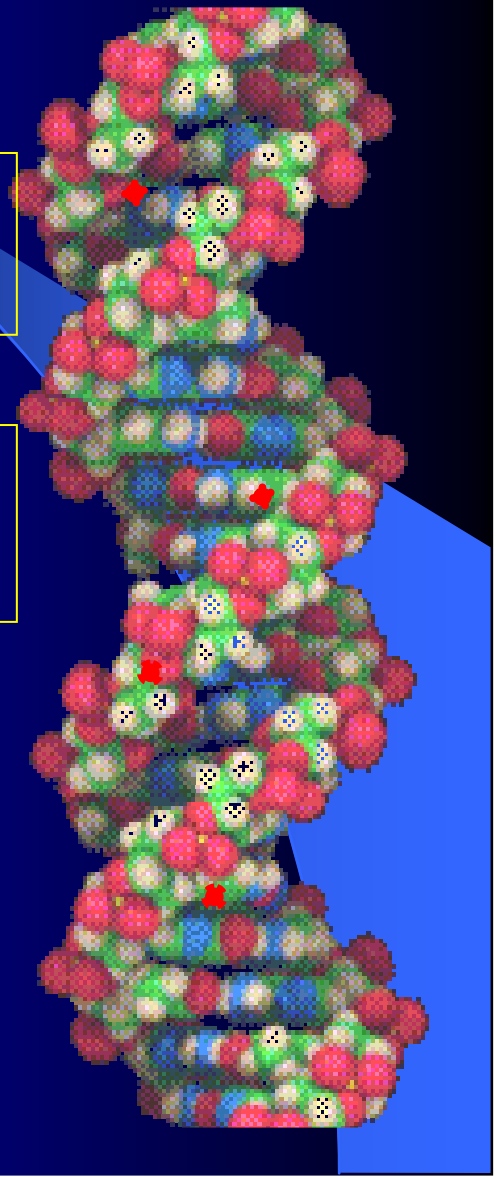
Formación de radicales libres

Lesiones en las cadenas del DNA

Defectos en el gen – p53 supresor de tumores

El riesgo individual en ausencia del gen codificador de la enzima $GSTM_1$

(Glutathion-S-transferasa M1)



Riesgos vinculados a la exposición al radón

FACTORES DE SUSCEPTIBILIDAD DEL CÁNCER DE PULMON

Table II. *Effect of GSTM1 and GSTT1 genes on risk of lung cancer.*

	Cases	Controls	OR[1]	95% CI	OR[2]	95% CI
GSTM1+	53	100	1	-------	1	--------
GSTM1-	72	87	1.54	0.97-2.44	1.72	0.99-2.99
GSTT1+	98	141	1	-------	1	--------
GSTT1-	27	46	1.19	0.69-2.05	1.01	0.53-1.93

[1]Adjusted for sex and age. Crude OR.

[2]Adjusted for sex, age, tobacco and occupational exposure to carcinogenic substances. Adjusted OR.

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

FACTORES DE SUSCEPTIBILIDAD DEL CANCER DE PULMON

Table III. *Interaction between GSTM1 and GSTT1 genes and smoking habit.*

	GSTM1				GSTT1			
	Cases	Controls	OR[1]	95% CI	Cases	Controls	OR[1]	95% CI
Non-smokers/gene present	1	42	1	-------	7	56	1	--------
Smokers/ gene present	52	58	100.55	10.76-939.97	91	85	28.85	7.92-105.17
Non-smokers/gene absent	9	35	7.74	0.89-67.45	3	21	1.09	0.23-5.08
Smokers/ gene absent	63	52	131.93	14.09-1235.74	24	25	28.03	6.92-113.52

[1]Adjusted for age and occupational exposure to chemical substances.

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

Riesgos vinculados a la exposición al radón

FACTORES DE SUSCEPTIBILIDAD DEL CÁNCER DE PULMON

Table IV. *Interaction between GSTM1 and GSTT1 genes and risk of lung cancer.*

	Cases	Controls	OR[1]	95% CI	OR[2]	95% CI
GSTM1+ / GSTT1+	41	82	1	-------	1	--------
GSTM1+ / GSTT1-	12	18	1.08	0.52-2.26	1.39	0.60-3.21
GSTM1- / GSTT1+	57	59	1.95	1.15-3.23	2.19	1.18-4.07
GSTM1- / GSTT1-	15	28	1.34	0.59-3.07	1.71	0.63-4.68

[1]Adjusted for sex and age. Crude OR

[2]Adjusted for sex, age, smoking habit and occupational exposure to carcinogenic substances. Adjusted OR.

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

REVISION DE GENES IMPLICADOS EN LA SUSCEPTIBILIDAD HUMANA AL CANCER DE PULMON

AÑO	AUTOR	GEN	OR	$IC_{95\%}$	PUBLICACIÓN
1994	Alexandrie et al	CYP1A1/GSTM1-	3.0 (SCC)	(1.2 - 7.2)	Carcinogen
1997	To-Figueiras et al	GSTM1 -	1.91(SCC)	(0.78 - 4.69)	Carcinogen
1997	Kelsey et al	GSTM1-/GSTT1-	2.9	(1.1 - 7.7)	Cancer C & Cont
1997	Rebbeck et al	GSTM1-/GSTT1-	3-5		C E Bio&Prev
1998	Jourenkova-Mironova et al	GSTM3AA/GSTP1(AG o GG)/ GSTM1- en GF*	2.7	1.2 – 6.0)	Pharmacogenetics
1999	To-Figueiras et al	GSTM1-	1.41	0.89 – 2.24)	Cancer C & Cont
2000	Stücker et al	GSTM1- + GF*	8.1	2.0 -31	Pharmacogen
2001	Hou et al	GSTM1 - + GF*(>23pq/año)	3.5	0.7 – 17.3	Envir & Mol Mut
2001	Bouchardy et al	GSTM1- +GSTM3+GSTP1	1.2 Caucas 1.5 Asiat 2.7	(1.1 – 1.4) (1.2 – 1.7) (1.2 –6.0)	Lung Cancer
2002	Stücker et al	GSTP1*B/*B+ GSTM1-	6.9	(1.6 – 30.2)	Carcinogen
2002	Perera et al	GSTM1- + GSTP1Val en Fumadores	4.68	(1.17 – 18.71)	Carcinogen
2003 2003	Miller et al Ruano-Raviña et al	GSTP1 GG + Tabac GSTM1 GSTM1- + Tabac GSTM1- + GSTT1+	13 1.7 24.5 2.19	(6.5 – 25) (1.0 – 3.0) (-59.1 –109.0) (1.18 – 4.07)	Epidemiology Antican Res
2004	Alexandrie et al	GSTM1-0/0 + NF	2.72 (SCC)	(1.32 – 5.90)	C E Bio & Prev
2004	Martín et al	XPC-Poly(AT) +/+ En SCC**	1.6 1.93	(1.01 – 2.55) (1.06 – 3.51)	C E Bio & Prev
2005	Wenzlaff et al	GSTM1- + NF*** GSTM1- + GSTP1Val	2.3** 4.56**	(1.05 – 5.13) (1.21 – 17.21)	Carcinogen

*Grandes fumadores. ** Small cell carcinoma. ***En No Fumadores expuestos a ETS más de 20 años.
Fuente: Elaboración propia.

Riesgos vinculados a la exposición al radón

FACTORES DE EFECTO DEL CÁNCER DE PULMON

Annals of Oncology Advance Access published September 25, 2007

original article

Annals of Oncology
doi:10.1093/annonc/mdm395

Analysis of the relationship between p53 immunohistochemical expression and risk factors for lung cancer, with special emphasis on residential radon exposure

A. Ruano-Ravina[1,2*], R. Pérez-Becerra[3], M. Fraga[3], K. T. Kelsey[4] & J. M. Barros-Dios[1,5]

[1]Department of Preventive Medicine and Public Health, University of Santiago de Compostela, Santiago de Compostela; [2]Galician Agency for Health Technology Assessment, Galician Department of Health Santiago de Compostela; [3]Department of Pathological Anatomy, Santiago de Compostela Clinical University Hospital, Santiago de Compostela Spain; [4]Department of Genetics and Complex Diseases, Harvard School of Public Health, Harvard University Boston, MA, USA; [5]Preventive Medicine Service, Santiago de Compostela Clinical University Hospital, Santiago de Compostela Spain

Received 17 March 2007; revised 10 July 2007; accepted 10 July 2007

Background: Indoor radon exposure has been postulated as the second risk factor of lung cancer after tobacco. The objective of this work is to analyze if there exists any effect on p53 immunohistochemical expression mainly due to radon exposure and other risk factors for lung cancer.

Patients and methods: The tumor samples of a case series of 163 lung cancer cases were analyzed to know the p53 staining. The staining was classified into four categories from no staining to intense staining (>60%). This staining was correlated with radon exposure, tobacco consumption, having worked in risk occupations for lung cancer and alcohol consumption.

Results: Only 72 samples could be analyzed for immunohistochemistry and some of these samples were sequenced from exons 4–8. No association was observed for staining intensity and radon exposure and also for tobacco and occupation. A slight association with a more intense staining was observed for high alcohol intake. In the four samples with a staining >60% that could be sequenced from exons 4 to 8, no mutation was observed in the p53 gene.

Conclusion: There is no association between radon exposure and p53 expression, indicating that maybe the effect of radon is not mediated through p53 alterations.

Key words: gene p53, immunohistochemistry, lung neoplasms, radon

original article

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Riesgos vinculados a la exposición al radón

Publicaciones de la OMS de la International Agency for Research on Cancer (IARC) :

Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 43. Man-made Mineral Fibresand Radon. Summary of Data Reported and Evaluation (1988)

Riesgos vinculados a la exposición al radón

Carcinógeno humano definido por la IARC

Grupo 1: Radón[10043-92-2] y sus productos de desintegración
(Vol. 43;1988)

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTTLA

Riesgos vinculados a la exposición al radón

Qué evidencias existen?

Biological Effects Ionizing Radiation

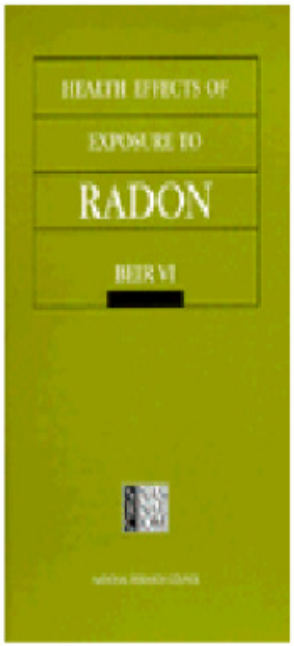
BEIR IV 1988

National Academy of Sciences)

Radón como riesgo

y 2ª causa de cáncer de pulmón

Riesgos vinculados a la exposición al radón



Free Executive Summary

Health Effects of Exposure to Radon: BEIR VI

Committee on Health Risks of Exposure to Radon (BEIR VI), National Research Council

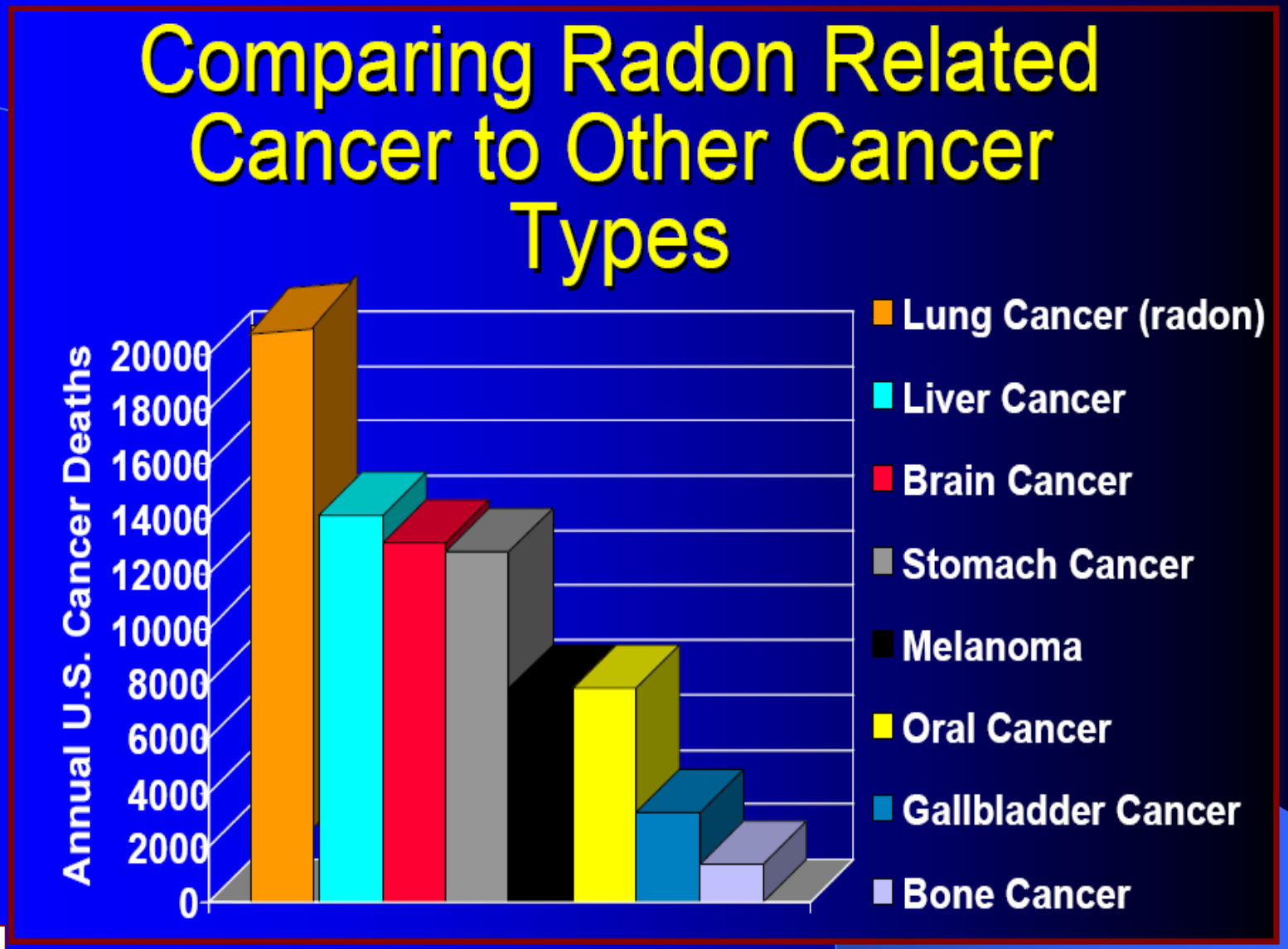
ISBN: 0-309-05645-4, 516 pages, 6 x 9, hardback (1999)

Riesgos vinculados a la exposición al radón

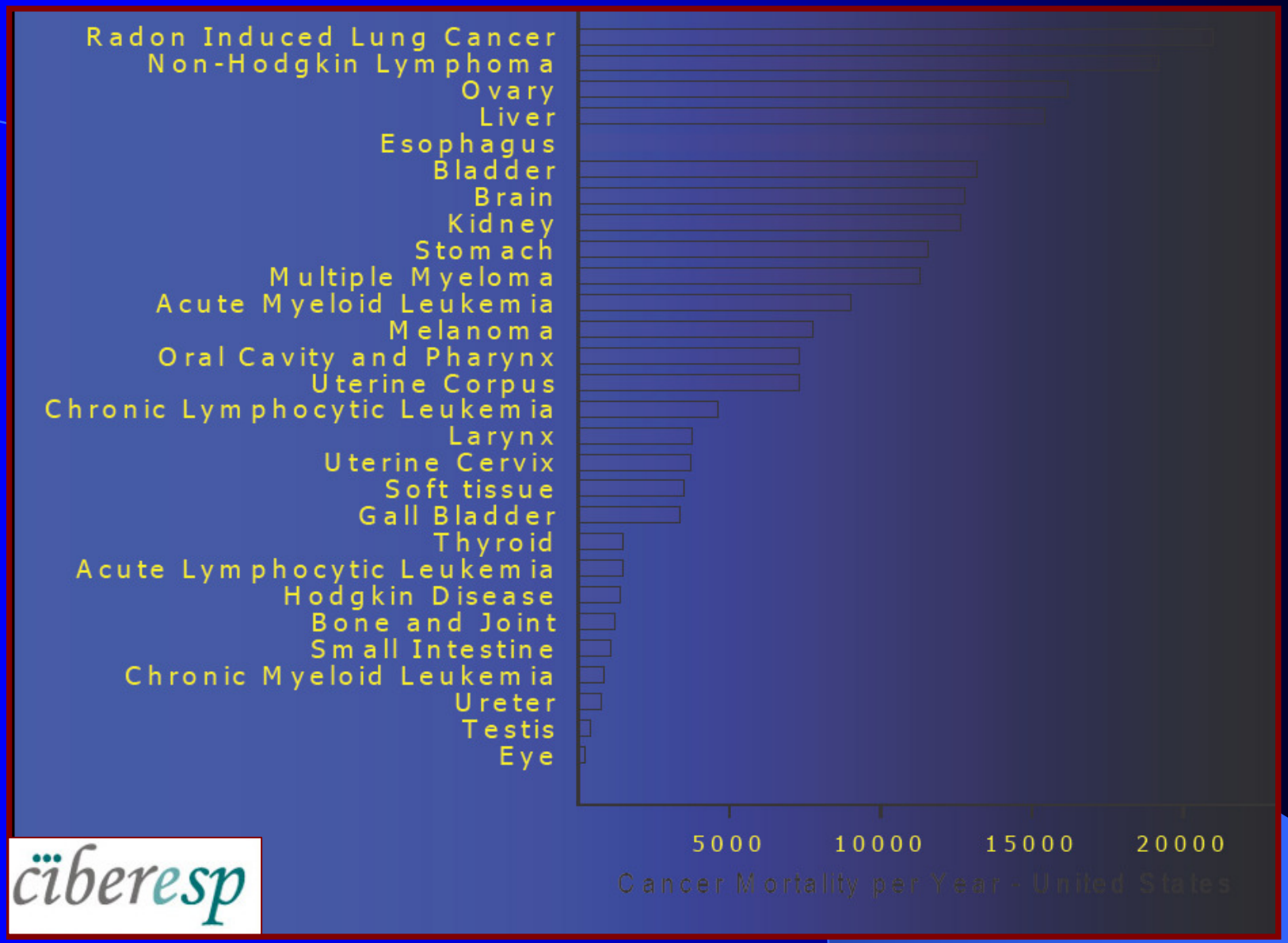
Table: Mortality from lung cancer among miners exposed to radon

Mines	Number of lung cancer deaths	
	Expected (without radon)	Observed
Colorado Plateau, USA	59	256
Ontario, Canada	68	152
Beaverlodge, Canada	34	65
Port Radium, Canada	25	57
West Bohemia, Czech Republic	138	702
Malmberget, Sweden	15	51
New Mexico, USA	17	68
Newfoundland, Canada	22	113
Yunnan Province, China	267	981
Cornwall, UK	67	105
Radium Hill, Australia	23	32
France	21	45
Total	**756**	**2627**

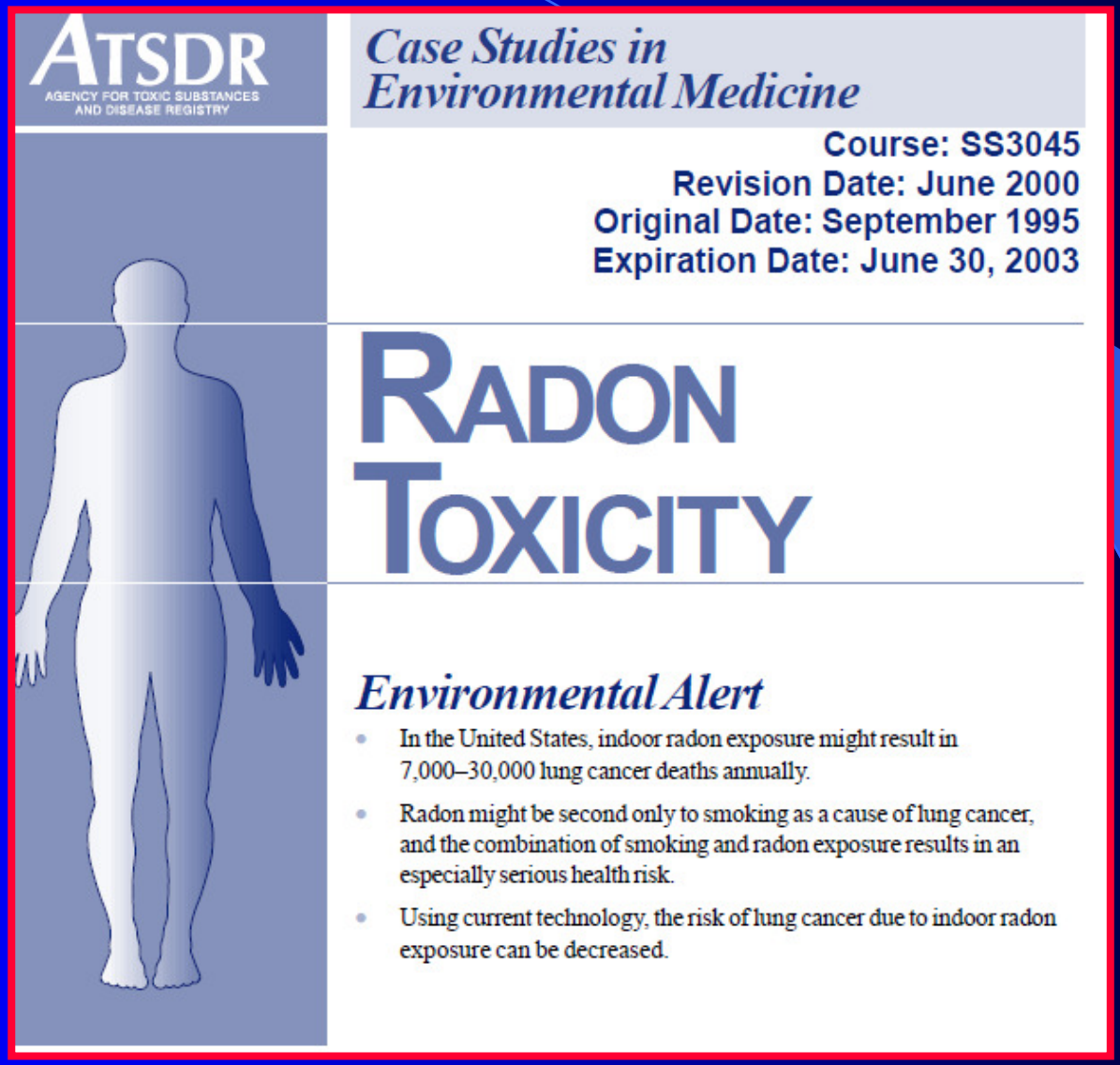
Riesgos vinculados a la exposición al radón



Riesgos vinculados a la exposición al radón



Riesgos vinculados a la exposición al radón



Riesgos vinculados a la exposición al radón

Table 1. Radon Risk Evaluation Chart if You Smoke

Radon Level	If 1,000 People Who Smoked Were Exposed to This Level Over a Lifetime...	The Risk of Cancer From Radon Exposure Compares to...	What To Do: Stop Smoking and...
20.0 pCi/L	About 250 men or 143 women could die of lung cancer	>100 times the risk of drowning	Consider fixing between 2 and 4 pCi/L
8.0 pCi/L	About 132 men or 66 women could die of lung cancer	>100 times the risk of dying in a home fire	Consider fixing between 2 and 4 pCi/L
4.0 pCi/L	About 66 men or 33 women could die of lung cancer	>100 times the risk of dying in an airplane crash	Consider fixing between 2 and 4 pCi/L
2.0 pCi/L	About 33 men or 16 women could die of lung cancer	>2 times the risk of dying in a car crash	Consider fixing between 2 and 4 pCi/L
1.0 pCi/L	About 16 men or 8 women could die of lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult)
0.4 pCi/L	About 8 men or 4 women could die of lung cancer	(Average outdoor radon level)	

*pCi/L: picocuries per liter.
If you are a former smoker, your risk might be lower.

Riesgos vinculados a la exposición al radón

Table 2. Radon Risk Evaluation Chart if You Have Never Smoked

Radon Level	If 1,000 People Who Never Smoked Were Exposed to This Level Over a Lifetime...	The Risk of Cancer From Radon Exposure Compares to...	What To Do:
20.0 pCi/L	About 33 men or 20 women could die of lung cancer	>2 times the risk of being killed in a violent crime	Consider fixing between 2 and 4 pCi/L
8.0 pCi/L	About 13 men or 8 women could die of lung cancer		Consider fixing between 2 and 4 pCi/L
4.0 pCi/L	About 6.4 men or 4 women could die of lung cancer	>10 times the risk of dying in an airplane	Consider fixing between 2 and 4 pCi/L
1.0 pCi/L	About 1.6 men or 1 woman could die of lung cancer	The risk of dying in a home fire (Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult)
0.4 pCi/L	Less than 1 person could die of lung cancer	(Average outdoor radon level)	

*pCi/L: picocuries per liter.
If you are a former smoker, your risk might be higher.

Riesgos vinculados a la exposición al radón

Primeros estudios en población general

Táboa 2.- Estudos Epidemiolóxicos. Exposición ao radón doméstico e Cancro de Pulmón.

Autor Lugar	Deseño Estudo	Suxeitos	Medida Exposición	Resultados
Lees Canadá	Casos e Controles	27 casos 49 controles	Medidas Anteriores o estudo	Asociación, non significativa
Svensson Suecia	Casos e Controles	Mulleres: 292 casos, 584 controles.	Detectores: filtro EDR-RDA	Asociación con Cancro de Células Pequenas
Axelson Suecia	Casos e Controles	177 casos 677 controles	Nalgunhas casas película alfa- sensíbel	Asociación
Svensson Suecia	Casos e Controles	Mulleres: 210 casos 209 controles p 191 controles h.		Asociación para Cancro de Células Pequenas
Koltz EEUU	Cohorte	752 persoas	Vivendas contaminadas residuos radiactivos	Asociación, non significativa
Schenberg EEUU	Casos e Controles	Mulleres: 433 casos 402 controles.	Detectores : Alpha-Track, e de carbón	Asociación
Blot China	Casos e Controles	Mulleres: 308 casos 356 controles	Detectores :Alpha-Track	Non Asociación
Rousteenoja Finlandia	Casos e Controles	Homes: 308 casos 434 controles	Detectores Alpha-Track.	Asociación
Biberman Israel	Casos e Controles	35 casos 35 controles	Detectores Alpha-track	Asociación
Pershagen Suecia	Casos e Controles	1.360 casos 2.847 controles	Detectores Alpha-track	Non asociación
Combinado: China, Estocolmo y New Jersey		Mulleres: 966 caos 1.183 controles		Non asociación
Létourneau Canadá	Casos e Controles	738 casos 738 controles	Detectores Alpha-Track	Non asociación
Alavanja EEUU	Casos e Controles	Mulleres brancas non fumadoras 538 casos 1.183 controles	Detectores Alpha-Track	Suxérese asociación co Adenocarcinoma
Alavanja EEUU	Casos e Controles	Mulleres non fumadoras: 618 casos 1.402 controles	Detectores Alpha-Track	Non asociación
Zaridze Rusia	Casos e Controles	Mulleres non fumadoras		Asociación
Auvinen Finlandia	Casos e Controles	517 casos 517 controles	Detectores Alpha-Track	Non asociación
Darby Inglaterra	Casos e Controles	982 casos 3.185 controles		Aumento do risco co aumento da dose
Lubin	Metaanálise	4.263 casos 6.612 controles		Asociación
Ruosteenoja Finlandia	Casos y Controles	291 casos 495 controles		Asociación non significativa.

Controles p: Controles poboacionais
Controles h: Controles hospitalarios

Riesgos vinculados a la exposición al radón

American Journal of Epidemiology
Vol. 156, No. 6
Printed in U.S.A.
DOI: 10.1093/aje/kwf070

Exposure to Residential Radon and Lung Cancer in Spain: A Population-based Case-Control Study

Juan Miguel Barros-Dios[1,2], María Amparo Barreiro[1], Alberto Ruano-Ravina[1], and Adolfo Figueiras[1]

[1] Department of Preventive Medicine and Public Health, School of Medicine, University of Santiago de Compostela, Santiago de Compostela, Spain.
[2] Preventive Medicine Unit, Santiago de Compostela University Teaching Hospital, Santiago de Compostela, Spain.

Received for publication July 26, 2001; accepted for publication May 8, 2002.

Riesgos vinculados a la exposición al radón

TABLE 2. Effect of radon concentration on the risk of lung cancer, Spain, 1992–1994

Radon concentration*		No. of subjects		Crude analysis		Adjusted analysis†	
Bq/m³	pCi/liter	Cases	Controls	OR‡	95% CI‡	OR	95% CI
0–36.9	0.0–0.9	28	73	1.00	1.15, 3.75	1.00	1.21, 6.18
37.0–55.1	1.0–1.4	43	54	2.08	1.05, 3.34	2.73	1.12, 5.48
55.2–147.9	1.5–3.9	46	64	1.87	1.30, 4.36	2.48	1.29, 6.79
≥148.0	≥4.0	42	46	2.38	1.30, 4.36	2.96	1.29, 6.79

* Categorized in quartiles for all subjects and expressed in Bq/m³ and pCi/liter.

† Adjusted for age, sex, family history, and lifetime tobacco consumption (measured in packs and categorized in quartiles).

‡ OR, odds ratio; CI, confidence interval.

American Journal of Epidemiology (2002)

Riesgos vinculados a la exposición al radón

TABLE 3. Interaction between exposure to radon and lifetime tobacco consumption, Spain, 1992–1994

Lifetime tobacco consumption	Radon concentration		No. of subjects		Adjusted* analysis	
	Bq/m³	pCi/liter	Cases	Controls	OR†	95% CI†
Nonsmokers	0–36.9	0.0–0.9	2	28	1.00	
	≥37.0	≥1.0	11	76	1.81	0.33, 10.09
Smokers	0–36.9	0.0–0.9	24	43	20.16	3.43, 118.55
	≥37.0	≥1.0	118	85	46.45	8.46, 254.85

* Adjusted for age, sex, and family history.

† OR, odds ratio; CI, confidence interval.

American Journal of Epidemiology (2002)

Riesgos vinculados a la exposición al radón

Table 3. **Summary results of meta-analyses relating indoor radon and lung cancer**

Study	Adjusted odds ratio[a] at 150 Bq/m³
Blot et al. (1990)	0.95 (0.93–0.97)[b]
Shoenberg et al. (1992)	3.06 (2.46–3.79)
Pershagen et al. (1992)	1.38 (1.37–1.40)
Alavanja et al. (1994)	1.07 (0.99–1.16)
Létourneau et al. (1994)	0.98 (0.93–1.04)
Pershagen et al. (1994)	1.18 (1.13–1.23)
Auvinen et al. (1996)	1.02 (0.99–1.04)
Ruosteenoja et al. (1996)	1.47 (1.05–2.04)
Darby et al. (1998)	1.16 (1.06–1.27)
Alavanja et al. (1999)	0.81 (0.72–0.90)
Field et al. (2000)	1.49 (1.35–1.65)
Sobue et al. (2000)	1.32 (0.63–2.73)
Kreienbrock et al. (2001)	1.03 (0.93–1.14)
Lagarde et al. (2001)	1.43 (1.19–1.72)
Pisa et al. (2001)	1.92 (1.06–3.50)
Wang et al. (2002)	1.19 (1.14–1.25)
Barros-Dios et al. (2002)	2.69 (1.34–5.39)
Overall	1.24 (1.11–1.38)
Overall results of meta-analysis by exposure level (Bq/m³)	
50	1.07 (1.04–1.11)
100	1.15 (1.07–1.24)
200	1.33 (1.15–1.54)
250	1.43 (1.19–1.72)

[a] Estimates of single studies fitted from the weighted log–linear regression models.
[b] Figures in parentheses are 95% confidence intervals.

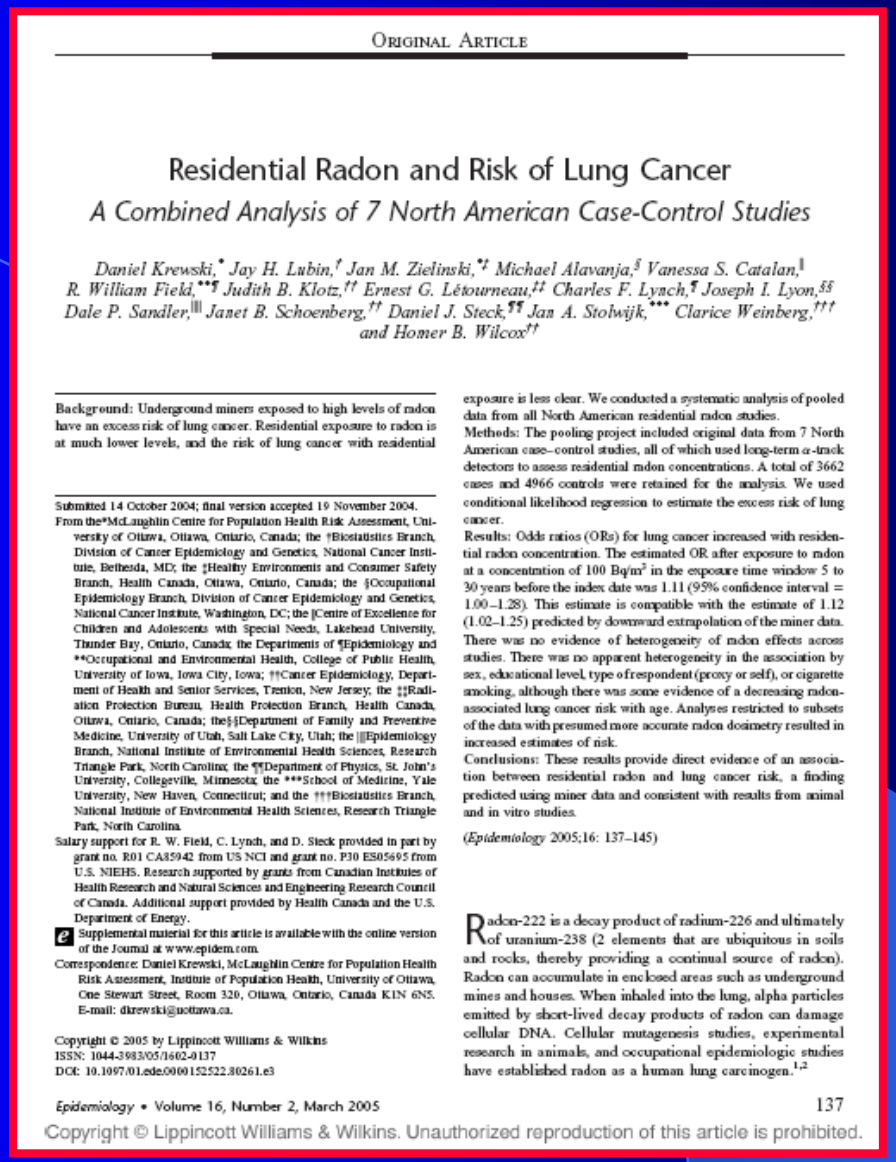
Research

Meta-analysis of residential exposure to radon gas and lung cancer

Maria Pavia,[1] Aida Bianco,[1] Claudia Pileggi,[1] & Italo F. Angelillo[1]

Bulletin of the World Health Organization 2003;81:732-738

Riesgos vinculados a la exposición al radón



ORIGINAL ARTICLE

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[††]*

Background: Underground miners exposed to high levels of radon have an excess risk of lung cancer. Residential exposure to radon is at much lower levels, and the risk of lung cancer with residential exposure is less clear. We conducted a systematic analysis of pooled data from all North American residential radon studies.

Methods: The pooling project included original data from 7 North American case–control studies, all of which used long-term α-track detectors to assess residential radon concentrations. A total of 3662 cases and 4966 controls were retained for the analysis. We used conditional likelihood regression to estimate the excess risk of lung cancer.

Results: Odds ratios (ORs) for lung cancer increased with residential radon concentration. The estimated OR after exposure to radon at a concentration of 100 Bq/m^3 in the exposure time window 5 to 30 years before the index date was 1.11 (95% confidence interval = 1.00–1.28). This estimate is compatible with the estimate of 1.12 (1.02–1.25) predicted by downward extrapolation of the miner data. There was no evidence of heterogeneity of radon effects across studies. There was no apparent heterogeneity in the association by sex, educational level, type of respondent (proxy or self), or cigarette smoking, although there was some evidence of a decreasing radon-associated lung cancer risk with age. Analyses restricted to subsets of the data with presumed more accurate radon dosimetry resulted in increased estimates of risk.

Conclusions: These results provide direct evidence of an association between residential radon and lung cancer risk, a finding predicted using miner data and consistent with results from animal and in vitro studies.

(*Epidemiology* 2005;16: 137–145)

Submitted 14 October 2004; final version accepted 19 November 2004.

From the*McLaughlin Centre for Population Health Risk Assessment, University of Ottawa, Ottawa, Ontario, Canada; the †Biostatistics Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, MD; the ‡Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario, Canada; the §Occupational Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, Washington, DC; the ‖Centre of Excellence for Children and Adolescents with Special Needs, Lakehead University, Thunder Bay, Ontario, Canada; the Departments of ¶Epidemiology and **Occupational and Environmental Health, College of Public Health, University of Iowa, Iowa City, Iowa; ††Cancer Epidemiology, Department of Health and Senior Services, Trenton, New Jersey; the ‡‡Radiation Protection Bureau, Health Protection Branch, Health Canada, Ottawa, Ontario, Canada; the§§Department of Family and Preventive Medicine, University of Utah, Salt Lake City, Utah; the ‖‖Epidemiology Branch, National Institute of Environmental Health Sciences, Research Triangle Park, North Carolina; the ¶¶Department of Physics, St. John's University, Collegeville, Minnesota; the ***School of Medicine, Yale University, New Haven, Connecticut; and the †††Biostatistics Branch, National Institute of Environmental Health Sciences, Research Triangle Park, North Carolina.

Salary support for R. W. Field, C. Lynch, and D. Steck provided in part by grant no. R01 CA85942 from US NCI and grant no. P30 ES05695 from U.S. NIEHS. Research supported by grants from Canadian Institutes of Health Research and Natural Sciences and Engineering Research Council of Canada. Additional support provided by Health Canada and the U.S. Department of Energy.

Supplemental material for this article is available with the online version of the Journal at www.epidem.com.

Correspondence: Daniel Krewski, McLaughlin Centre for Population Health Risk Assessment, Institute of Population Health, University of Ottawa, One Stewart Street, Room 320, Ottawa, Ontario, Canada K1N 6N5. E-mail: dkrewski@uottawa.ca.

ISSN: 1044-3983/05/1602-0137
DOI: 10.1097/01.ede.0000152522.80261.e3

Radon-222 is a decay product of radium-226 and ultimately of uranium-238 (2 elements that are ubiquitous in soils and rocks, thereby providing a continual source of radon). Radon can accumulate in enclosed areas such as underground mines and houses. When inhaled into the lung, alpha particles emitted by short-lived decay products of radon can damage cellular DNA. Cellular mutagenesis studies, experimental research in animals, and occupational epidemiologic studies have established radon as a human lung carcinogen.[1,2]

Riesgos vinculados a la exposición al radón

- *British Medical Journal 2004*: Estudio colaborativo de 13 investigaciones europeas (pooling study)
- *Epidemiology 2005*: Analisis combinado de 7 estudios de C-C norteamericanos
- *Health Physics 2005*:"Pooling" estudio de dos casos-controles en Alemania
- *Int J Cancer 2005*: Estudio C_C sobre cáncer de pulmón, radón domiciliario, y dieta en una región mediterránea.

Riesgos vinculados a la exposición al radón

Cite this article as: BMJ, doi:10.1136/bmj.38308.477650.63 (published 21 December 2004)

Papers

Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies

S Darby, D Hill, A Auvinen, J M Barros-Dios, H Baysson, F Bochicchio, H Deo, R Falk, F Forastiere, M Hakama, I Heid, L Kreienbrock, M Kreuzer, F Lagarde, I Mäkeläinen, C Muirhead, W Oberaigner, G Pershagen, A Ruano-Ravina, E Ruosteenoja, A Schaffrath Rosario, M Tirmarche, L Tomášek, E Whitley, H E Wichmann, R Doll

Riesgos vinculados a la exposición al radón

Br Med J 2004

7.148 casos de cáncer pulmonar de 13 países europeos

14.208 controles

Media de años de exposición al Rn residencial: 5.34 años

Niveles medios de Rn:

Casos: 104 Bq/m^3 Controles: 97 Bq/m^3

Nivel de incremento del riesgo en sujetos con medidas de radón directas: 8,4% [3,0 – 15,8] por cada 100 Bq/m^3

Nivel de incremento del riesgo en sujetos con exposición ajustadando el error aleatorio de las medidas: 16% [5 – 31]

Riesgos vinculados a la exposición al radón

Epidemiology 2005

Siete estudios de casos y controles realizados en Norteamérica.

3.662 casos de cáncer pulmonar

4.966 controles

Exposición de 5 a 30 años

Incremento del riesgo por cada 100 Bq de 11% (similar al 11,2% estimado en los estudios de mineros)

World Pooling of Case-control Studies of Residential Radon and Lung Cancer

Confidential Preliminary Results

Please send all comments on these results to radon@ctsu.ox.ac.uk before 15 Dec 2009

Riesgos vinculados a la exposición al radón

Health Physics 2005

Dos estudios de casos y controles realizados en Alemania entre 1990 y 1997.

2.963 casos de cáncer pulmonar.

4.232 controles

Exposición de 5 a 35 años.

Concentración media de Rn: 61 Bq/m^3

Ajustados por tabaco y exposición a asbesto, los riesgos resultan ser, con referencia a la exposición a menos de 50 Bq, de:

OR=0,97 de 50 a 80 Bq

OR=1,06 de 80 a 140 Bq

OR=1,40 para más de 140 Bq

El incremento, lineal, por cada 100 Bq fue de 0,10[-0,02-0,30]

Y en los de menor movilidad residencial de 0,14 [-0,03 –0,55]

ciberesp

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Laboratorio de Radón de Galicia

UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Residential Radon and Lung Cancer

To the Editor:

Residential radon exposure causes lung cancer. The International Agency for Research on Cancer declared radon as a human carcinogen in 1988.[1] Evidence for this statement is based mainly on studies in miners[2] and residential case-control studies.[3,4] There are no published cohort studies assessing the relationship between residential radon exposure and the development of lung cancer.

Between 1992 and 1994, we enrolled 241 randomly selected controls in a population-based case-control study on residential radon and lung cancer by using 1991 census data for the Santiago de Compostela Health District.[5] Initially, 500 persons from the general population were selected through sex-stratified random sampling. Of these, 391 met the eligibility criteria and 241 were finally included (32% refused and 5% were not located after 3 attempts).

Participants younger than 35 years of age, those with previous cancers, and those who had lived fewer than 5 years in the same dwelling were excluded. All participants were personally interviewed on lung cancer risk factors, and radon concentration was measured in the main bedroom under standard conditions.

Cohort follow-up ended on 31 May 2007. For each cohort member, the vital status was assessed through 2 databases: hospital records at the Clinic University Hospital of Santiago de Compostela and the Galician Mortality Registry, which covers the whole Galician population. The survival outcomes were (*a*) alive, (*b*) death from a cause other than cancer, (*c*) incidence or death from cancer other than lung cancer, and (*d*) incidence or death from lung cancer. Radon exposure at baseline was compared among persons without cancer, those with cancer other than lung cancer, and those with lung cancer at the end of the follow-up.

TABLE 1. Baseline Cohort Characteristics and Radon Relative Risks (1992–1994)

Variable	Initial Cohort (Baseline Characteristics) n = 211	Cancer Other Than Lung Cancer n = 25	Lung Cancer n = 5
Age (%)[a]			
35–50	71 (34)	7 (28)	0 (0)
51–70	106 (50)	12 (48)	3 (60)
>70	34 (16)	6 (24)	2 (40)
Men (%)	187 (89)	19 (76)	5 (100)
Current smoking[a] (%)	77 (36)	9 (36)	2 (40)
Quartiles of lifetime smoking in packets (only for ever smokers)[a]			
25	5	2	12
50	11	11	21
75	18	17	32
Have lived >20 yr in the same residence (%)	127 (60)	52 (52)	4 (80)
Quartiles of radon concentration (Bq/m^3)			
25	30	35	85
50	52	52	226
75	117	96	729
Subjects above the EPA level (148 Bq/m^3) (%)	41 (20)	3 (12)	3 (60)
RR (CI 95%)	1.00	0.68 (0.2–2.2)	6.6 (1.2–38)

[a]Baseline characteristics of those subjects who developed lung or other cancer type on the follow-up.

We could find determine outcome status of 211 persons (88%); median follow-up was 12 years. During the follow-up, 11% (25 subjects) had developed some type of cancer, of whom 5 had lung cancer. Tobacco consumption was similar among groups at the baseline (Table 1). The median radon concentration was 226 Bq/m^3 among future lung cancer cases and 52 Bq/m^3 among all others. All lung cancer cases lived in the same dwelling until the end of the follow-up. The crude relative risk for lung cancer among those exposed to radon concentrations higher than 148 Bq/m^3 compared with nonexposed was 6.6 (95% confidence interval = 1.2–38), whereas the relative risk for any cancer type was 0.68 (0.2–2.2).

To our knowledge these are the first cohort data on residential radon exposure and lung cancer, and the results confirm an association. Residential radon concentration in those who developed lung cancer was 4.5-fold higher than the radon concentration in the other groups, the median concentration being far above the action level considered by EPA or European Union (148 and 200 Bq/m^3, respectively).

This study has a small sample size, which does not allow a detailed analysis. Nevertheless, these are the first data of their kind and add evidence that radon concentration predicts the risk of lung cancer years before its onset. An advantage in this investigation is that the proportion of smokers was similar among the study groups, and therefore, we believe that the higher lung cancer incidence in those exposed to higher radon concentrations is not due to higher tobacco consumption.

Other researchers who have conducted residential case-control studies may be able to add to these results using larger samples.

Alberto Ruano-Ravina
Department of Preventive Medicine and Public Health
University of Santiago de Compostela
Santiago de Compostela, Galicia, Spain
CIBER de Epidemiología y Salud Pública (CIBERESP)
Barcelona, Spain
Galician Agency for Health Technology Assessment
Department of Health
Santiago de Compostela, Galicia, Spain

Miguel Conde Rodríguez
Ferrol Health Department
Galician Health Service
Ferrol, Galicia, Spain

Sara Cerdeira-Caramés
Service of Epidemiology
Galician Directorate of Public Health
Santiago de Compostela, Galicia, Spain

Juam M. Barros-Dios
Department of Preventive Medicine and Public Health
University of Santiago de Compostela
Santiago de Compostela, Galicia, Spain
CIBER de Epidemiología y Salud Pública (CIBERESP)
Barcelona, Spain
Service of Preventive Medicine
University Hospital of Santiago de Compostela
Galician Health Service
Santiago de Compostela, Galicia, Spain

REFERENCES

1. IARC. Man-made mineral fibres and radon. IARC monographs on the evaluation of carcinogenic risks to humans. 1988;43:39.
2. Darby SC, Whitley E, Howe GR, et al. Radon and cancers other than lung cancer in underground miners: a collaborative analysis of 11 studies. *J Natl Cancer Inst*. 1995;87:378–384.
3. Darby S, Hill D, Auvinen A, et al. Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies. *BMJ*. 2005;330:223–227.
4. Krewski D, Lubin JH, Zielinski JM, et al. Residential radon and risk of lung cancer: a combined analysis of 7 North American case-control studies. *Epidemiology*. 2005;16:137–145.
5. Barros-Dios JM, Barreiro MA, Ruano-Ravina A, et al. Exposure to residential radon and lung cancer in Spain: a population-based case-control study. *Am J Epidemiol*. 2002;156:548–555.

Riesgos vinculados a la exposición al radón

INTERNATIONAL RADON PROJECT 2005-2007

How does the project work?

IRP working groups:

- Risk Assessment
- WHO Exposure Guidelines
- Cost Effectiveness
- Measurement and Mitigation
- Risk Communication
- Coordination and Evaluation

Network and working group meetings

Production of Radon-related databases, reports and recommendations

Project coordination through WHO

Time to act

The largest contribution to environmental radiation in many countries comes from radon

The science is clear: the dangers of radon exposure are well established

Effective ways to reduce radon levels are available

The challenge

Translating scientific knowledge into public health action to minimize the health risks for the population.

The WHO IRP project will contribute to this through a concerted effort of partners from all over the world.

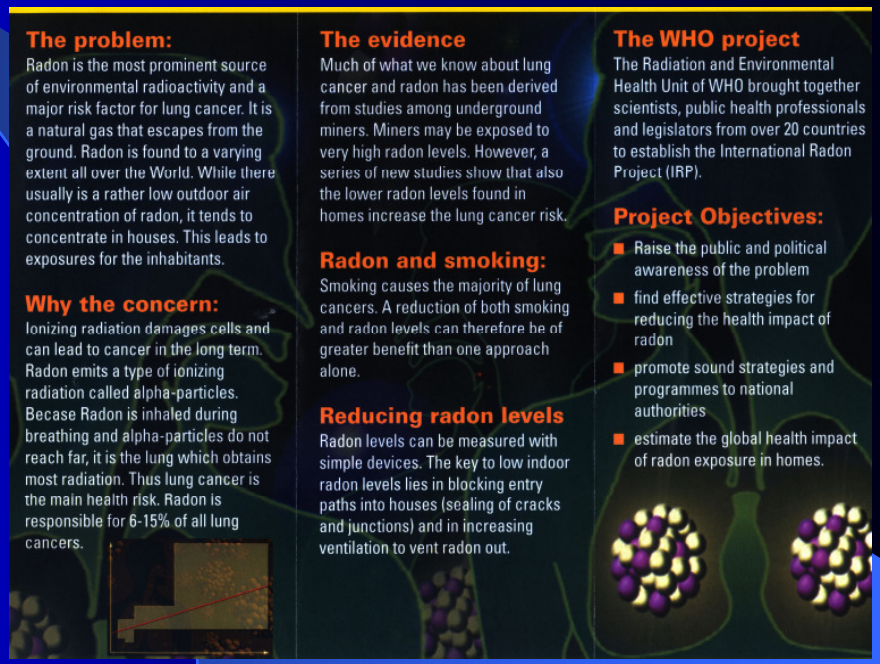
Membership is open to any WHO member state government, i. e. department of health, or representatives of other national institutions concerned with radiation research and protection.

Radiation and Environmental Health Unit
Protection of the Human Environment

World Health Organization
20, avenue Appia
1211 Geneva 27 Switzerland
Tel. : +41 22 791 3964
Fax : +41 22 791 4123
e-mail: radiation@who.int

A global project to increase awareness on **radon** and health support action to decrease **radon** levels in homes

World Health Organization



The problem:

Radon is the most prominent source of environmental radioactivity and a major risk factor for lung cancer. It is a natural gas that escapes from the ground. Radon is found to a varying extent all over the World. While there usually is a rather low outdoor air concentration of radon, it tends to concentrate in houses. This leads to exposures for the inhabitants.

Why the concern:

Ionizing radiation damages cells and can lead to cancer in the long term. Radon emits a type of ionizing radiation called alpha-particles. Becase Radon is inhaled during breathing and alpha-particles do not reach far, it is the lung which obtains most radiation. Thus lung cancer is the main health risk. Radon is responsible for 6-15% of all lung cancers.

The evidence

Much of what we know about lung cancer and radon has been derived from studies among underground miners. Miners may be exposed to very high radon levels. However, a series of new studies show that also the lower radon levels found in homes increase the lung cancer risk.

Radon and smoking:

Smoking causes the majority of lung cancers. A reduction of both smoking and radon levels can therefore be of greater benefit than one approach alone.

Reducing radon levels

Radon levels can be measured with simple devices. The key to low indoor radon levels lies in blocking entry paths into houses (sealing of cracks and junctions) and in increasing ventilation to vent radon out.

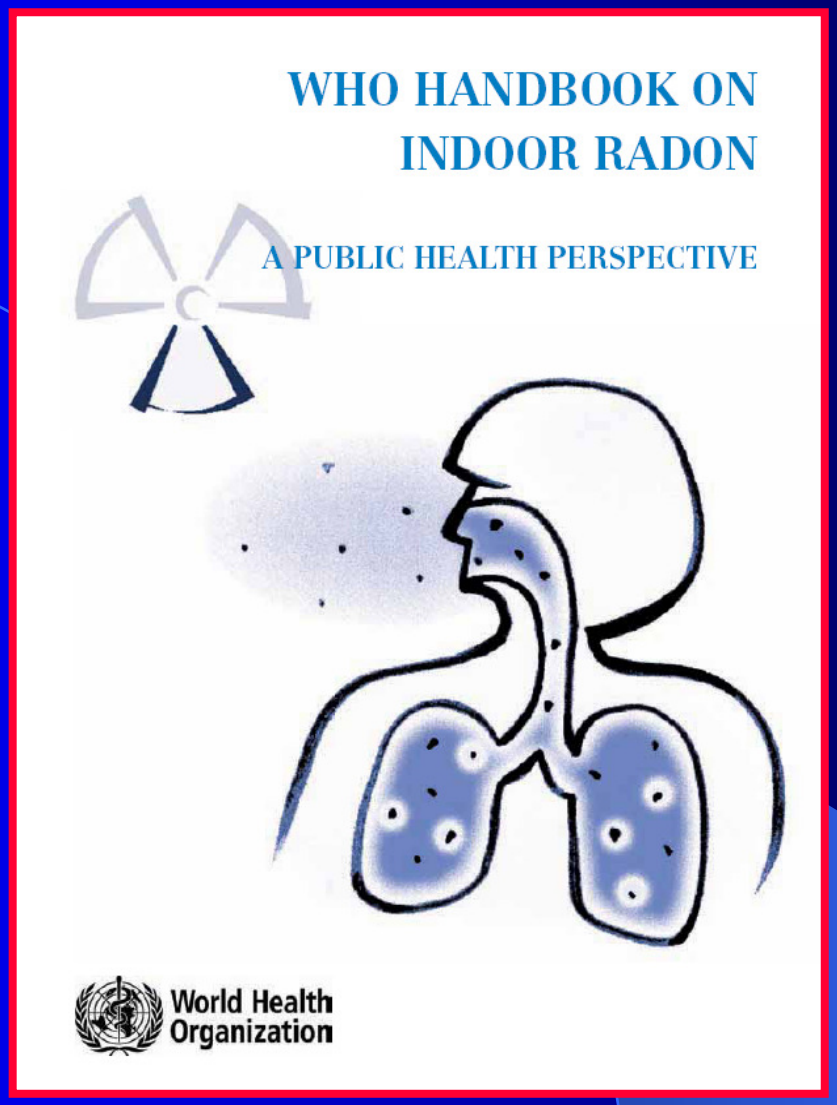
The WHO project

The Radiation and Environmental Health Unit of WHO brought together scientists, public health professionals and legislators from over 20 countries to establish the International Radon Project (IRP).

Project Objectives:

- Raise the public and political awareness of the problem
- find effective strategies for reducing the health impact of radon
- promote sound strategies and programmes to national authorities
- estimate the global health impact of radon exposure in homes.

Riesgos vinculados a la exposición al radón



http://apps.who.int/bookorders/anglais/detart1.jsp?sesslan=1&codlan=1&codcol=15&codcch=763

Riesgos vinculados a la exposición al radón

Contents

http://apps.who.int/bookorders/anglais/detart1.jsp?sesslan=1&codlan=1&codcol=15&codcch=763

Riesgos vinculados a la exposición al radón

1. Health effects of radon

KEY MESSAGES

- Epidemiological studies confirm that radon in homes increases the risk of lung cancer in the general population. Other health effects of radon have not consistently been demonstrated.
- The proportion of all lung cancers linked to radon is estimated to lie between 3% and 14%, depending on the average radon concentration in the country and on the method of calculation.
- Radon is the second most important cause of lung cancer after smoking in many countries. Radon is much more likely to cause lung cancer in people who smoke, or who have smoked in the past, than in lifelong non-smokers. However, it is the primary cause of lung cancer among people who have never smoked.
- There is no known threshold concentration below which radon exposure presents no risk. Even low concentrations of radon can result in a small increase in the risk of lung cancer.
- The majority of radon-induced lung cancers are caused by low and moderate radon concentrations rather than by high radon concentrations, because in general less people are exposed to high indoor radon concentrations.

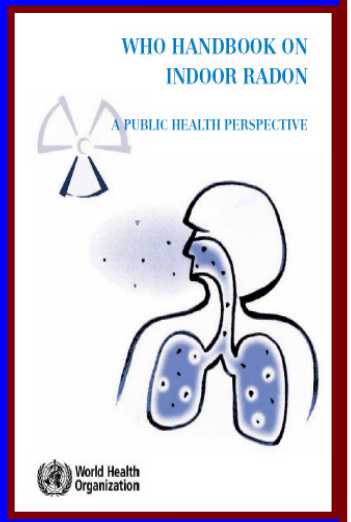
Riesgos vinculados a la exposición al radón

Table 5. Estimates of the proportion of lung cancer attributable to radon in selected countries

Country	Mean indoor radon [Bq/m³]	Risk estimate used in calculation	Percentage of lung cancer attributed to radon [%]	Estimated no. of deaths due to radon-induced lung cancer each year
Canada (Brand et al. 2005)	28	BEIR VI	7.8	1 400
Germany (Menzler et al. 2008)	49	European pooling study[a]	5	1 896
Switzerland (Menzler et al. 2008)	78	European pooling study[a]	8.3	231
United Kingdom (AGIR 2009)	21	European pooling study[a]	3.3	1 089
		BEIR VI	6	2 005
France (Catelinois et al. 2006)	89	European pooling study	5	1 234
		BEIR VI	12	2 913
United States (BEIR VI, 1999)	46	BEIR VI	10-14	15 400 - 21 800

[a] with adjustment for year-to-year variation in indoor radon concentrations.

Riesgos vinculados a la exposición al radón

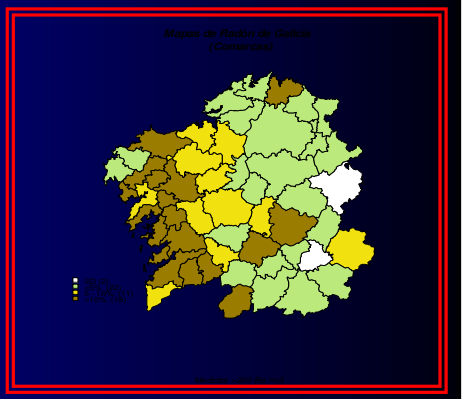


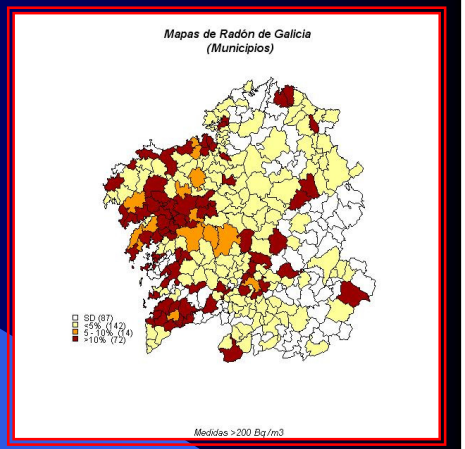
6. National radon programmes

6.2.1 Radon maps

Geographical-based radon surveys estimate the distribution of radon in various areas. This information can identify radon-prone areas and may be represented on a radon potential map. If the data are obtained by properly designed surveys, these maps can be a useful tool in implementing a national radon policy. The radon map should be used as a tool to optimize the search for homes with high radon concentrations and to identify areas for special preventive actions during new construction. Radon maps based on indoor measurements covering the whole country have been produced in countries such as the United Kingdom, the USA and Ireland (Miles et al. 2007, USEPA 1993, Fennell et al. 2002).

Radon maps may provide information for identifying high-risk or radon-prone areas, and for motivating radon measurements and mitigation in existing buildings and preventive measures in new buildings. However, radon levels within an area will not be uniform and indoor radon concentrations will generally follow a log-normal distribution. Maps should be used mainly for targeting resources to the radon-prone areas, rather than indicating areas where measurements are not needed.





http://apps.who.int/bookorders/anglais/detart1.jsp?sesslan=1&codlan=1&codcol=15&codcch=763

Riesgos vinculados a la exposición al radón

Why did the World Health Organization initiate the International Radon Project ?

WHO's International Agency for Research on Cancer - Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 43. Man-made Mineral Fibres and Radon. Summary of Data Reported and Evaluation (1988)

5.5 Evaluation

There is *sufficient evidence* for the carcinogenicity of radon and its decay products in experimental animals.

There is *sufficient evidence* for the carcinogenicity of radon and its decay products in humans.

Overall evaluation

Radon and its decay products are *carcinogenic to humans (Group 1).*

Riesgos vinculados a la exposición al radón

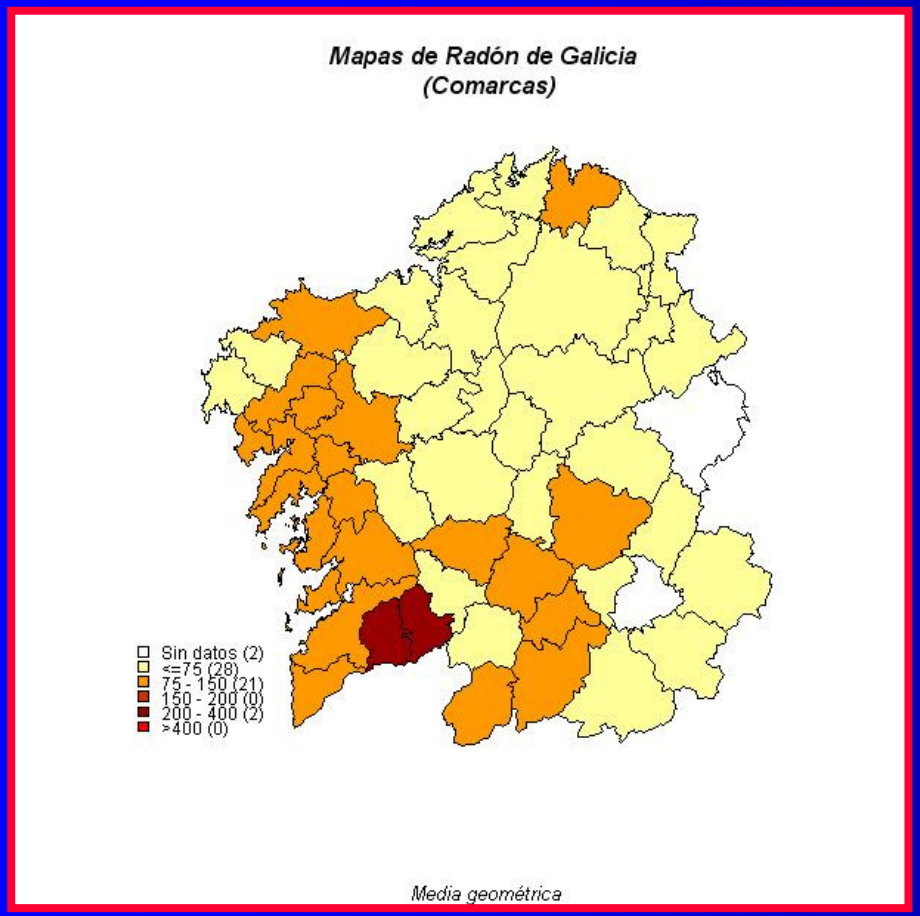
The International Radon Project WHO –IRP(2005-2007)

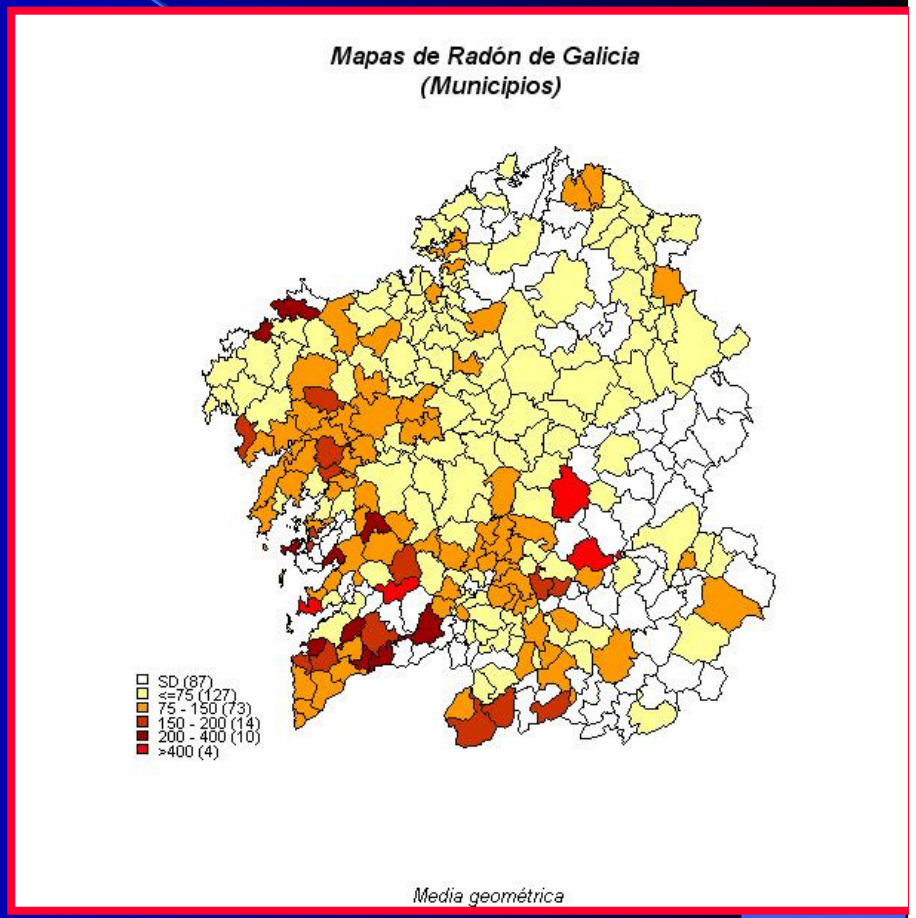
"Recientes hallazgos de estudios de Casos y controles sobre cáncer de pulmón y exposición a radón en las casas realizados en numerosos países han llegado a substanciales logros en el cálculo de la estimación de riesgos y consolidan el conocimiento de esa relación mediante el análisis conjunto (pooling study) de los datos de esos estudios. La consistencia de dichos resultados de lo sestudios de casos y controles de Europa, Norteamérica y China, proveen un fuerte argumento para una iniciativa para reducir los riesgos del radón."

Riesgos vinculados a la exposición al radón

Mapa gallego de radón según media geométrica en comarcas y municipios (2.376 domicilios a julio de 2009)

Laboratorio de Radón de Galicia

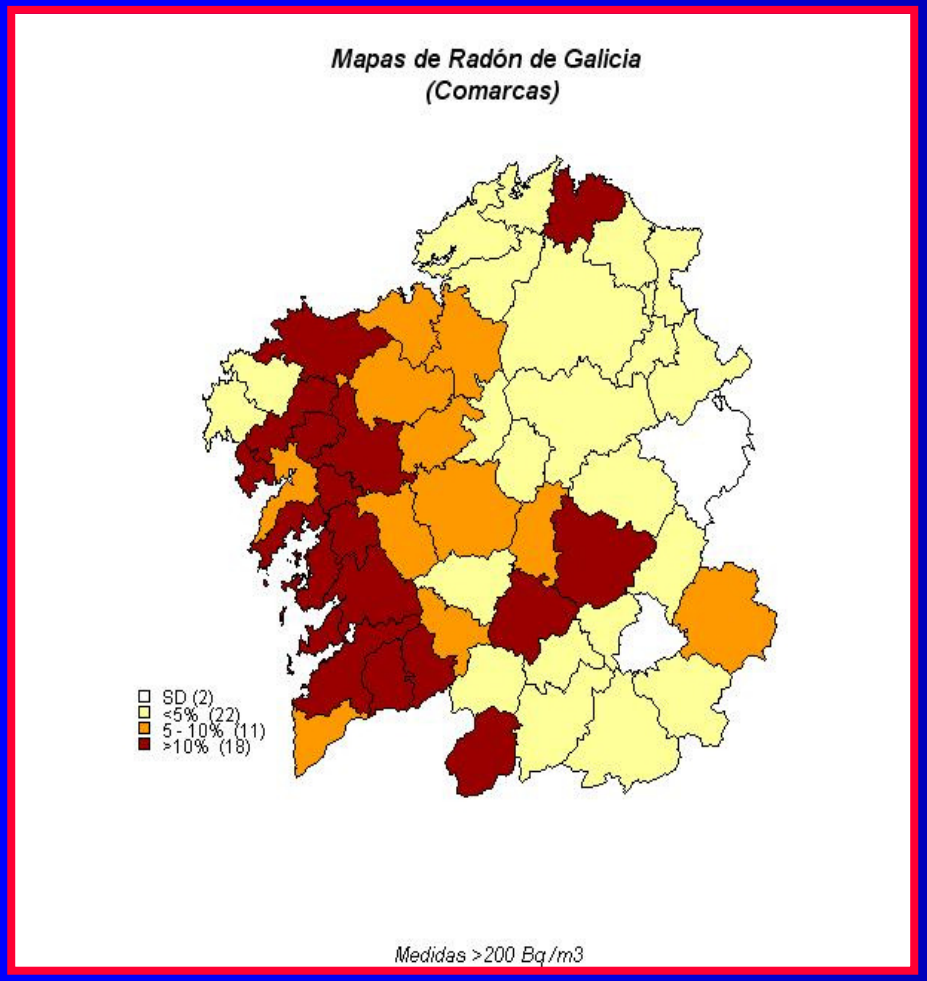


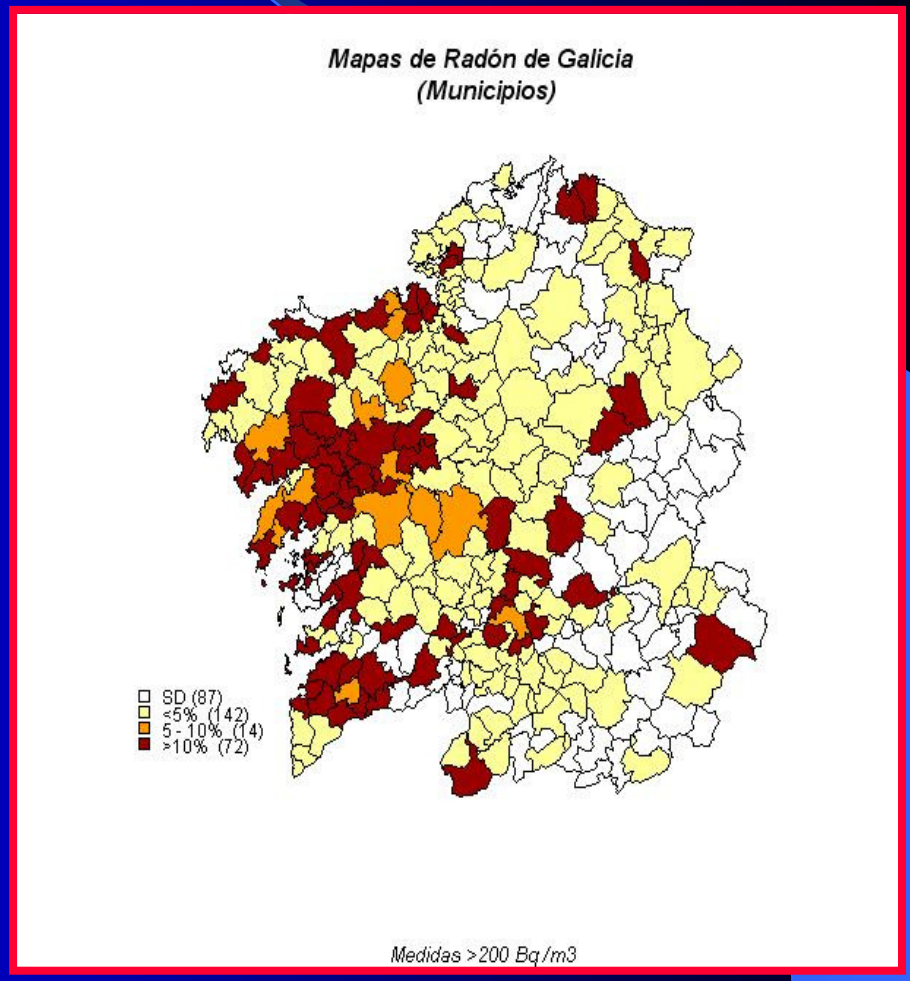


USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

Riesgos vinculados a la exposición al radón

Mapa gallego de radón según % > 200 Bq/m3
en comarcas y municipios(2.376 domicilios a julio de 2009)
Laboratorio de Radón de Galicia





Riesgos vinculados a la exposición al radón

Actitud de administraciones y sectores profesionales implicados

Riesgos vinculados a la exposición al radón

2008-Normas de Hábitat (Consellería de Vivenda, Xunta de Galicia)

2009-Documento OMS

2010- (25/02/2010) Moción en el Senado español para realizar mapas de radón e introducir en la legislación las normas constructivas.

2010- Abril : Eliminación de toda referencia a radón en las "nuevas" Normas de Hábitat (Xunta de Galicia)