

Supplementary Submission

to

Le Bureau d'audiences publiques sur l'environnement

from

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**The BAPE has not received accurate information
from federal government authorities on the
Health Risks of Radon Exposures and
the adequacy of current standards to
prevent radon-induced lung cancer**

November 27, 2014

DR. GORDON EDWARDS

~ *biographical notes* ~

November 2014

Gordon Edwards graduated from the University of Toronto with a Gold Medal in Mathematics and Physics (1961). He earned Master's degrees in Mathematics (1962) and English Literature (1964) at the University of Chicago under a Woodrow Wilson Fellowship. He taught Mathematics and Literature at the University of Western Ontario, for four years, then obtained a Ph.D. in Mathematics from Queen's University (1972).

In 1970 he became the editor of *Survival*, an environmental newsletter with subscribers in 13 countries. In 1973 he coordinated a 7-volume study of the Role of Mathematics in Canadian Industry, Government, and Science for the Science Council of Canada. In 1974 he joined the Faculty of Vanier College where he taught until his retirement in June 2010. In 1975 he co-founded the Canadian Coalition for Nuclear Responsibility (CCNR) and rose to prominence as one of Canada's best known independent experts on nuclear technology, uranium, and weapons proliferation. He created the CCNR website: www.ccnr.org.

Dr. Edwards first became involved in the issues of uranium mining at the Cluff Lake Board of Inquiry Into Uranium Mining in Saskatchewan where he testified and cross-examined witnesses for three weeks. He became involved in reactor safety, radioactive wastes and plutonium recycling at the Ontario Royal Commission on Electric Power Planning in 1977-78, where he testified and cross-examined witnesses for three months. In 1978, the Royal Commission reported that Edwards' estimate for the probability of a meltdown in a CANDU reactor was "more realistic" than the industry's. That same year, Dr. Edwards showed the cancer risk from radon gas is higher than government authorities claimed. These results were confirmed by the BC Medical Association, by an independent study ordered by Atomic Energy Control Board, and by the US National Academy of Sciences.

Dr. Edwards played a role in public debates that resulted in permanent bans on uranium exploration in Nova Scotia and British Columbia. He testified on uranium issues to the Territorial Assembly of the Northwest Territories in Yellowknife on three separate occasions in the 1980's. In the 1990's, and in 2007 and 2010, he participated in public meetings in Baker Lake and Iqaluit on possible impacts of a proposed uranium mine.

In the late 1990's Dr. Edwards was invited, along with representatives from the industry-owned Nuclear Waste Management Organization, to brief Inuit communities on the management of high-level radioactive waste from nuclear power plants. The Inuit Grand Council recommended that the government of Canada stop producing these wastes.

Dr. Edwards has served as a consultant to governmental and non-governmental bodies, such as the Auditor General of Canada, the Ontario Royal Commission on Electric Power Planning, Select Committee on Ontario Hydro Affairs, United Steelworkers of America, and Siting Task Force for Radioactive Wastes. He has worked with aboriginal groups: Assembly of First Nations, Congress of Aboriginal Peoples, Mohawks of Kanasetake, Inuit Tapiriit Kanitami, Cree Nation of James Bay, and Chippewas of Nawash.

He was awarded the Nuclear-Free Future Award (2006) and YMCA Peacekeeper Medallion (2013). He has given keynote addresses at conferences on such topics as "Nuclear Waste" in Stockholm (2007), "Uranium Mining" in Salzburg (2008), "Medical Aspects of Nuclear Energy" in Ottawa (PGS 2009), "Prevention of Nuclear War" in Basel (IPPNW 2010), "Fukushima Consequences" in Hong Kong (2012), "Nuclear Labyrinth on the Great Lakes" in Ohio (2013), and "Remediation Efforts at Fukushima" in Winnipeg (2014).

For a complete Curriculum Vitae see http://ccnr.org/GE_CV.pdf

Radon Standards should not be portrayed as “safe levels”

This communication demonstrates that Canada’s regulatory standards for radon exposure, both for workers (in uranium mines) and for the public (in homes), are neither safe, nor are they as low as reasonably achievable. In fact they pose a significant risk of lung cancer for those so exposed.

The CNSC is not providing objective scientific information (as required by Article 7 of the Nuclear Safety and Control Act) when it categorically states that such standards are “safe” and when it implies that those exposed to radon gas are not at risk of dying from a radon-induced lung cancer if their exposures are kept within these regulatory limits.

(1) Previous standard for radon in homes: 800 Bq/m³ (becquerels per cubic metre)

As noted by the *Régie régionale de santé et des services sociaux des Laurentides* in their 1998 publication “Le Radon à Oka”, the permissible level of radon in homes set by Health Canada at that time was 800 becquerels per cubic metre (Bq/m³) of air. That limit, which remained in force until 2007, was twice as high as the limit in any of the countries of the European Community and four to eight times higher than the limit in most other countries. (See Appendix A)

The *Régie* utilized mortality data from the US National Academy of Sciences’ BEIR-VI Report (“Health Effects of Exposure to Radon”) to show that, if they were exposed at Health Canada’s permissible level of exposure over an extended period of time, smokers would experience an extra frequency of lung cancers of 1 in 10 or more, while non-smokers would experience an extra frequency of lung cancers of about 1 in 100 or more. (See Appendix B)

Since about 5 out of 100 smokers are known to die of lung cancer currently, chronic exposure to 800 Bq/m³ would ADD another 10 out of 100 lung cancers to give a total of 15 lung cancers per 100 smokers. That is a TRIPLING of the lung cancer rate among smokers!

For non-smokers, the lung cancer death rate is currently about 5 out of 1000. Chronic exposure to 800 Bq/m³ would add another 10 cases per 1000, for a total of 15 lung cancers per 1000 non-smokers. Again, that is a TRIPLING of the lung-cancer rate among non-smokers.

The fact that Canadian government would regard such a standard as “acceptable” for so many years, prior to the involvement of provincial health authorities, is an indictment of the degraded “safety culture” at the federal level when it comes to public exposures to atomic radiation.

(2) Current standard for radon in homes: 200 Bq/m³.

Under pressure from the provinces, Health Canada in 2007 reduced the permissible level for radon in homes to 200 Bq/m³. In other words, they reduced the previous limit by a factor of four. However, this is still double the limit of 100 Bq/m³ recommended by the World Health Organization in 2009. (See Appendix A.)

According to the linear model of radiation carcinogenesis, reducing the radiation exposure by any given factor will reduce the excess cancers (i.e. the radiation-induced cancers) by the same factor. So reducing radon exposure fourfold will reduce the radon-caused lung cancers fourfold.

For smokers chronically exposed at this reduced limit, there will be about $10/4 = 2.5$ extra lung cancers per 100, for a total of 7.5 lung cancers per 100. That's a 50 percent increase in lung cancer mortality for smokers. The same percentage increase applies to non-smokers, even though the absolute numbers are 10 times less. Thus the current standard for radon in homes would allow a 50 percent increase of lung cancers for smokers and non-smokers alike.

Altogether, the lung cancer rate in society would go from 55 per 1000 to 82.5 per 1000, if people were chronically exposed at the current permissible level of 200 Bq/m^3 – an admittedly unlikely scenario for the country as a whole, but not so unlikely for certain communities or for certain sub-populations.

This standard is far from safe, and it is far from acceptable – especially for new homes. The WHO, in recommending a limit of 100 Bq/m^3 for ALL homes in 2009, made a special plea for new homes – saying that all countries should be “implementing radon prevention in building codes to reduce radon levels in homes under construction”

At the very least it is unacceptable that a federal agency like the Canadian Nuclear Safety Commission or Health Canada, would ever describe such a level of radon exposure as “safe”. Canadian citizens, and Canadian decision makers, are entitled to know the truth.

It is dishonest for our regulatory bodies to claim that they adhere to the ALARA principle – that all radiation exposures be kept “As Low As Reasonably Achievable” – when those same regulatory bodies set limits that are unnecessarily lax and distinctly sub-optimal.

Quebec should not defer to the federal government on matters of radiation standards, which not only adversely affect the lives of Quebecers but also the economics of health care in Quebec.

(3) Thirty Years of Inaction – The Evidence Was There in 1978

It is a sobering thought that the federal authorities not only allowed a level of radon in homes very much higher than any other country in the western world until quite recently, and that even now the federal government has set a radon standard for homes that is twice as high as that recommended by the WHO – one that would allow for a 50 percent increase in lung cancer rates, under the worst exposure scenario, in communities that are particularly afflicted.

What is even worse is that the government of Canada knew 36 years ago that chronic exposure to these levels of radon gas in homes would cause an unacceptable increase in lung cancer rates. And Canada did nothing about it until the provinces insisted on tightening the radon standard.

In 1978, I testified as an expert witness at the Ontario Environmental Hearings on the proposed radon standards for new housing projects in Elliot Lake. The Ontario Ministry of Housing had proposed a standard of 0.02 WL (WL = working levels) as an “acceptable” level of radon in entire subdivisions of brand-new homes. This level of radon is equivalent to 148 Bq/m^3 – about 25 percent less than the current federal standard of 200 Bq/m^3 .

Using radiation mortality figures provided by the Ministry of Housing, I demonstrated to the panel that if people were chronically exposed at the proposed radon standard, one would expect to see at least a 31 percent increase in lung cancer – that’s about 17 extra lung cancers per 1000. So instead of 55 lung cancers per 1000 (smokers and non-smokers combined), one would see 72 lung cancers per 1000. To me, this did not seem an acceptable standard for brand new homes. A summary of my testimony, along with the Ministry of Housing’s radiation mortality figures, can be found at http://ccnr.org/lung_cancers.html . The document is entitled “Estimating Lung Cancers”, by Gordon Edwards. A hard copy has already been deposited with the BAPE.

Based on this stark evidence, I urged the panel to recommend that the proposed radon standard for new homes not be accepted as is, and that it be reassessed by an independent panel of health experts. The Environmental Panel agreed with my proposal and made a formal recommendation to that effect in their final report. However, no such independent reassessment ever took place.

In particular, the Atomic Energy Control Board (AECB) – the precursor of the Canadian Nuclear Safety Commission (CNSC) – continued to maintain that there would be no risk associated with the regulatory limits being proposed by the Ministry of Housing. Indeed, that same limit of 0.02 WL, or 148 Bq/m³, had earlier been promulgated by the AECB as the clean-up criterion for homes in Port Hope Ontario that had been contaminated with radon-generating wastes from the federally-owned Eldorado uranium refinery. The Ontario Ministry of Housing took their cue from the AECB, based on the false assumption that Canada’s nuclear regulator would not be advocating as a “safe” standard one that could be harmful, indeed life-threatening, to the public.

During the 1980 Royal Commission of Inquiry into Uranium Mining in British Columbia, the British Columbia Medical Association (BCMA) was so shocked by the disconnect between the alarming medical data on the one hand and the unfounded reassurances from the regulatory agency on the other hand that they called the AECB an agency that is “Unfit to Regulate”. In fact that is the title of Chapter XXII of the 360 page BCMA publication, “The Health Hazards of Uranium Mining”, published in 1980. See <http://ccnr.org/bcma.html> . A hard copy has already been deposited with the BAPE.

“The present average allowable exposure to the public [of 0.02 WL of radon exposure] could result in 200-300 extra cases of lung cancer per 10,000 people per lifetime. In light of current knowledge, this might be considered tantamount to allowing an industrially induced and publicly sanctioned epidemic of cancer.”

“That the AECB consistently and seriously neglected its statutory responsibility for the regulation of uranium mines is obvious to the most casual observer.”

from the BCMA Report, “Summary of Major Points”

The BCMA concluded that the 0.02 WL standard for radon in homes would result in 20-30 additional lung cancer deaths per 1000, rather than the 17 per 1000 that I had calculated. This discrepancy is not surprising, because I deliberately underestimated the number of cancer deaths by assuming that occupants were at home only 50% of the time, as opposed to the 70% or 80% occupancy time that is more realistically assumed by other analysts. (For 70% occupancy, I get $17 \times 7/5 = 23$ lung cancers; for 80% occupancy, my analysis gives $17 \times 8/5 = 27$ lung cancers.)

(4) The Thomas/McNeill Report, Commissioned by the AECB

The AECB, stung by the BCMA's public denunciation, commissioned an independent review of the health effects of radon, radium, and other alpha-radiation emitting materials. They hired a McGill epidemiologist, Duncan C. Thomas, and a physicist from the University of Toronto, K.G. McNeill, and told them to use only raw data from studies of exposed populations – avoiding the synopses or summaries published in other documents – to arrive at the best scientific estimates of cancers caused by exposure to radon, radium, and other alpha-emitting materials.

The Thomas/McNeill Report, entitled “Risk Estimates for the Health Effects of Alpha Radiation”, was published by the AECB in 1982 as INFO-0081. Their conclusions fully confirmed my earlier calculations: “a 0.02 WL maximum for homes could increase the lifetime lung cancer risk by about 40 percent”. That's about 22 extra lung cancer deaths per 1000 population. Again, not surprisingly, my 1978 estimate of 17 per 1000 was low because of my conservative assumption regarding occupancy time. See http://ccnr.org/thomas_report.html .

The Thomas/McNeill Report did not limit its consideration to radon in homes, but also addressed the standard for radon exposures of uranium miners. They found that if miners were to work at the regulatory limit for 11 years, the number of lung cancer deaths in that group would double.

At that time, the regulatory limit was expressed in terms of “working-level-months”, designated as WLM. This measure of exposure is obtained by multiplying the average number of “working levels” of radon by the number of “working months” of exposure. (A working month is based on 8 hours a day exposure.) Thus if a worker were exposed to 0.25 WL of radon for a period of 12 months, he would accumulate an exposure of $(0.25) \times 12 = 4$ working-level-months = 4 WLM.

Indeed, that was the regulatory limit set by the AECB for uranium miners: 4 WLM per year. The Thomas/McNeill Report : “Our best estimate of the effect of a 50-year occupational exposure to 4 WLM per year is 130 excess lung cancer deaths per 1000 persons . . . with a range from 60 to 250 per 1000.” Their best estimate corresponds to a 236 percent increase in lung cancer, with a range of uncertainty from a low of 109 percent increase in lung cancer to a high of 455 percent increase.

In absolute terms, this would mean a boost in the lung cancer death rate for uranium miners from 55 per 1000 to 185 per 1000, according to the best estimate, with a range of uncertainty from a low of 115 per 1000 to a high of 291 per 1000. Of course, such exposures would no longer be tolerated (although they once were!) but then the question is, who in their right mind would want to accept this as an acceptable regulatory limit?

If workers were to average only 1/10 of that limit in their radon exposures, then the number of excess lung cancers would also be reduced by a factor 10. Still, the Thomas/McNeill “best estimate” would yield an increase of 13 lung cancers per 1000 miners so exposed, and their most pessimistic estimate would give 45 extra lung cancers per 1000.

These are significant increases in lung cancer mortality. Workers have a right to know the risks.

(5) Estimated radon-induced lung cancer deaths among uranium miners today

The CNSC has informed the BAPE that under modern working conditions in the Canadian context, the radon exposures of uranium miners are so low that no “discernible” lung cancers would occur.

The CCNR agrees that if CNSC refuses to gather health statistics on the exposed miners, or fails to update those records for many decades to come, then the excess lung cancers that will occur among these workers will surely not be discernible. This protects the industry, but it does not protect the miners who are likely to experience at least 10 to 20 radon-induced lung cancers per 1000 workers during a 50-year working lifetime. The toll may in fact be much higher.

According to CNSC publication INFO-0813, the average 2006 radiation exposure for Canadian workers in underground uranium mines was 1.74 millisieverts (mSv). If this annual exposure rate were to persist for 50 years, the cumulative average exposure for underground uranium miners would be $1.74 \times 50 = 87$ mSv during a 50-year working lifetime.

(See http://www.stratecoinc.com/data/pdf/2011/CNSC_RadonandHealth_Feb2011.pdf)

In order to make use of the findings of the Thomas/McNeill Report, we need to convert the exposure level of 87 millisieverts (mSv) into working level months (WLM). This conversion is given by the Canadian Centre for Occupational Safety and Health (CCOSH) : 1 WLM = 5 mSv. (See http://www.ccohs.ca/oshanswers/phys_agents/ionizing.html)

So 87 mSv corresponds to $87/5 = 17.4$ WLM. The Thomas/McNeill Report indicates that 44 WLM will cause a doubling of the lung cancer rate among both smokers and non-smokers, thereby adding an additional 55 radon-induced lung cancers per 1000 to the existing incidence of 55 lung cancers per 1000.

So 17.4 WLM will cause $(55/44) \times 17.4 = 22$ extra lung cancers according to the “best estimate” given by Thomas and McNeill. That’s a 40 percent increase in lung cancer incidence. (77 per 1000 as opposed to 55 per 1000)

It may be that the 17.4 mSv radiation dose accumulated by these miners is not all due to radon and its alpha-emitting progeny (polonium-218 and polonium-214), but even if only half of that dose is from radon, we would still see 11 extra lung cancers per 1000. That’s still a 20 percent increase in lung cancer incidence. (66 per 1000 as opposed to 55 per 1000)

Conclusion

Canadian authorities have consistently misled Canadians – including uranium workers, members of the public, decision-makers and their official advisors, such as the BAPE Panel – about the extent of the dangers of radon as well as other alpha emitting radioactive materials. In particular, existing standards of radon exposure in homes as well as existing levels of radon exposures in uranium mines pose serious health risks to those exposed for their working lifetimes. However those health risks fade into insignificance in comparison with the potential health risks associated with the future dispersal of radium-bearing uranium tailings, whether accidental or deliberate.

Appendix A

World Health Organization, 2004

<http://www.who.int/phe/radiation/en/2004Radon.pdf>

Table 1. Domestic radon concentrations and Action Levels in different countries

Country	Average radon concentration in homes (Bq/m ³)	Action Level (Bq/m ³)
Czech Republic	140	200
Finland	123	400
Germany	50	250
Ireland	60	200
Israel	*	200
Lithuania	37	100
Luxembourg	*	250
Norway	51-60	200
Poland	*	400
Russia	19-250	*
Sweden	108	400
Switzerland	75	400
United Kingdom	20	200
European Community	*	400
USA	46	150
Canada	*	800

* not available at the moment

This table reveals that, as of 2004, Canada did not compile statistics on radon levels in homes as was done in many other countries. Canada was not taking the radon-in-homes problem seriously even though the USA and many other countries had identified it as a major public health priority.

In 2009, WHO suggested 100 Bq/m³ as a limit for radon in homes, “but if this level cannot be reached under the prevailing country-specific conditions, the reference level should not exceed 300 Bq/m³”. At the same time, WHO specified that special attention should be given to preventing high radon levels in new homes, suggesting that countries should be “implementing radon prevention in building codes to reduce radon levels in homes under construction”.

See <http://www.who.int/mediacentre/factsheets/fs291/en/> .

Appendix B

Excerpts from “Le Radon à Oka” by

**Estimation du risque relatif de développer un cancer du poumon
pour une exposition à vie au radon domestique
chez les fumeurs**

Exposition Bq/m ³	Modèle exposition - âge - concentration		Modèle exposition - âge - durée	
	Hommes	Femmes	Hommes	Femmes
25	1,081	1,089	1,054	1,059
50	1,161	1,177	1,108	1,118
100	1,318	1,352	1,214	1,235
150	1,471	1,525	1,318	1,352
200	1,619	1,694	1,420	1,466
400	2,174	2,349	1,809	1,915
800	3,120 ¹¹	3,549	2,507	2,760

pouvons estimer, tout en étant conservateur, que *pour un fumeur* le risque de développer un cancer du poumon relié à des niveaux d'exposition résidentielle au radon de 800 Bq/ m³ et plus pendant toute la durée de sa vie, prenant en considération une fréquentation normale d'un domicile, représente facilement un risque avec un ordre de grandeur 10⁻¹, c'est à dire 1 personne sur 10 et plus.

**Estimation du risque relatif de développer un cancer du poumon
pour une exposition à vie au radon domestique
chez les non-fumeurs**

Exposition Bq/m ³	Modèle exposition - âge - concentration		Modèle exposition - âge - durée	
	Hommes	Femmes	Hommes	Femmes
25	1,194	1,206	1,130	1,137
50	1,388	1,411	1,259	1,274
100	1,775	1,821	1,518	1,547
150	2,159	2,229	1,776	1,819
200	2,542	2,637	2,033	2,091
400	4,057	4,255	3,053	3,174
800	7,008 ¹⁴	7,440	5,058	5,317

estimer, tout en étant conservateur, que *pour un non-fumeur* le risque de développer un cancer du poumon relié à des niveaux d'exposition résidentielle au radon de 800 Bq/m³ et plus pendant toute la durée de sa vie, prenant en considération une fréquentation normale d'un domicile, représente facilement un risque avec un ordre de grandeur 10⁻² c'est-à-dire 1 personne sur 100 et plus.