



Verifying Canadian Nuclear Energy Worker Radiation Risk:

A Reanalysis of Cancer Mortality in
Canadian Nuclear Energy Workers (1957-1994)

SUMMARY REPORT

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EXECUTIVE SUMMARY

In 2005, the International Agency for Research on Cancer (IARC) released a 15-country study on the mortality of nuclear energy workers (NEWs). This study showed a statistically significant increase in the risk of mortality from all cancers excluding leukaemia in relation to radiation exposure, with Canadian data the chief driving force behind the worldwide results. The CNSC commissioned a reanalysis of the Canadian portion of the data to understand the unexpected findings. The study is now complete and summarized in this document.

Reanalysis Main Findings

The main findings and recommendations from this reanalysis are:

- Approximately 42,200 NEWs from Hydro-Québec, New Brunswick Power Corporation, Ontario Hydro, and Atomic Energy of Canada Limited (AECL), first employed since 1965, had no increase in risk of solid cancer mortality in relation to radiation exposure.
- A group of 3,088 AECL NEWs first employed before 1965 (1956-1964) was the only group of workers with a consistent radiation-associated increase in risk of solid cancer mortality. The risk estimate was statistically significant and was nine times higher than the risk estimates for workers with zero dose. This group of AECL NEWs had a profound impact on the Canadian and 15-country study findings.
- It is very likely that these early AECL NEWs have incomplete dose information (i.e., their doses are under-reported).
- Despite this apparent increase in cancer risk among early AECL NEWs, a comparison using the Canadian Mortality Database showed statistically significant lower rates of all causes of death and cancer mortality for this group than for the general Canadian population. This fact reinforces CNSC concerns that there remains a data problem as opposed to a true increase in their risk of solid cancer mortality.
- Further investigation of this group of early AECL NEWs is necessary to ensure the accuracy and completeness of radiation dose records in the National Dose Registry (NDR).

Conclusions and Path Forward

- The CNSC's reanalysis confirms that there is no increased cancer risk among any Canadian nuclear power plant workers for any time period or for AECL NEWs first employed since 1965.
- While the data suggests an increased solid cancer mortality risk for AECL NEWs first employed before 1965 (1956-1964), a comparison using the Canadian Mortality Database shows lower rates of all causes of death and cancer mortality for this group than for the general Canadian population.
- The CNSC does not have confidence in the historical AECL dose data (1956-1964). The apparent increase in the risk of solid cancer mortality for these early AECL NEWs deserves further investigation.
- The CNSC, Health Canada and AECL are further assessing the dose data of early AECL NEWs to resolve the existing outstanding issues. Health Canada has agreed not to share the Canadian cohort for any further epidemiological research until the quality of the data file has been confirmed.

INTRODUCTION

Ionizing radiation is one of the most extensively studied carcinogens (1). NEWs are occupationally exposed to ionizing radiation. This exposure is closely monitored and subject to dose limits and ALARA requirements set by the Canadian Nuclear Safety Commission (CNSC) to protect the health of workers. Dose information is submitted to the National Dose Registry (NDR) annually and tracked to ensure workers' doses are within regulatory limits.

A primary interest of nuclear regulators like the CNSC is to establish direct estimates of cancer risk as a result of prolonged low dose and low dose rate occupational radiation exposure. This information is important to strengthen the scientific basis of radiation protection standards for occupational radiation exposures to NEWs and environmental radiation exposures to members of the public.

In 2005, IARC released a 15-country study on cancer mortality among NEWs. This study showed a statistically significant increase in the risk of mortality from all cancers excluding leukaemia in relation to radiation exposure, with Canadian NEWs being the chief driving force behind the worldwide results. These findings were different from prior studies of Canadian NEWs.

The CNSC commissioned a reanalysis of the Canadian NEW data to understand this unexpected finding. The study is now complete and summarized in this document.

BACKGROUND

Over the years, there have been several studies conducted on the mortality of Canadian NEWs. These have involved different number of workers, sources of data, and have been combined with studies of NEWs from different countries. With the exception of the 15-country study (2, 9), there was no statistically significant risk of cancer mortality from occupational radiation exposures found in these studies. For clarity, Table 1 presents the chronology of Canadian NEW studies as well as international studies including Canadian NEWs.

Table 1: Chronology of Studies Involving Canadian Nuclear Energy Workers

Study Author	Year	# of Workers	Countries	Source of Data	Findings
Gribbin <i>et al.</i> (3)	1993	8,977	Canada: AECL only	AECL	No significant risk of cancer
IARC – Cardis <i>et al.</i> (4)	1995	95,673	3 countries: UK, US, Canada	AECL	No significant risk of cancer
Zablotska <i>et al.</i> (5)	2004	45,468	Canada: nuclear workers	National Dose Registry	Increased but non-significant risk of cancer
IARC – Cardis <i>et al.</i> (2, 9)	2005, 2007	407,391	15 countries	National Dose Registry	Significant excess risk of cancer found in Canadian cohort

In 2005, IARC released a 15-country study on cancer mortality among NEWs. This study showed a statistically significant increase in the risk of mortality from all cancers excluding leukaemia in relation to radiation exposure (2). This risk estimate was twice as high as the risk estimate for solid cancer mortality observed in the Life Span Study (LSS) (6) of the Japanese atomic bomb survivors exposed to higher doses at high dose rates (7,8). The LSS (6) is the largest most comprehensive epidemiology study ever performed, with more than 60 years of exposure follow-up. It is the most important source of scientific information on the health effects of ionizing radiation exposure.

The 15-country study reported that NEWs from Canada had the highest mortality risk for all cancers excluding leukaemia among the 15 countries (7 times higher than the average for the 15 countries) and this risk was statistically significant. The risk estimate for leukaemia was also increased, but was not statistically significant. For this analysis, Ontario Hydro NEWs were excluded because of missing socio-economic status data.

Exclusion of the Canadian cohort from the study reduced the risk estimate by 40% and materially changed it from statistically significant to statistically non-significant and brought the findings more in line with previous studies and the LSS. It is clear that the Canadian NEWs were the chief driving force behind the worldwide high cancer mortality risk estimates.

An earlier Canadian study by Zablotska et al. (5) using the same Canadian cohort that contributed to the 15-country study had come to a different conclusion. That study included all Ontario Hydro NEWs and found a sizeable (2.80 times higher) but statistically non-significant increase in risk of solid cancer mortality from 1957 to 1994 among Canadian NEWs, looking at chronic exposure to low dose, low dose rate ionizing radiation. It included all former and current employees of four Canadian nuclear facilities (AECL, Hydro-Québec, New Brunswick Power Corporation, and Ontario Hydro) registered in the National Dose Registry (NDR).

This apparent discrepancy in the results between the Canadian study and the 15-country study, despite that they were based on the same data, has attracted a lot of attention and questions regarding the Canadian data. The CNSC was concerned why the Canadian cancer mortality risk estimate was so much higher than the other countries in the 15-country study. To better understand the issue; in 2005, the CNSC launched an in-depth examination of the original data sources that contributed to both studies.

Actions Taken by CNSC to Understand the Discrepancy between the Two Studies

In December 2005, the CNSC held a meeting with several Canadian stakeholders involved in this issue to shed some light on the 15-country study results. At the meeting, results from unpublished analysis were presented showing that the risk estimate for AECL NEWs was different from the risk estimate for NEWs from other Canadian nuclear facilities. This assessment suggested that the elevated value of the whole cancer risk estimate for the Canadian cohort was driven exclusively by AECL.

In order to better understand the origins of the discrepancy between the Canadian (5) and the 15-country study (2, 9) the CNSC initiated a comparison of the methodologies used in both studies. This comparison included a detailed review of all dose records and a reanalysis of mortality in the Canadian cohort with particular emphasis on AECL employees. During the detailed review of the dosimetry practices at AECL, as well as of the protocols for data validation, verification, storage, and transfer to the NDR, a potentially significant gap in reporting the zero doses to the NDR before 1971 was discovered (10, 11). This discovery triggered an in-depth examination of the original data sources that contributed to both studies (10).

The CNSC then proceeded with a reanalysis of the Canadian cohort using corrected dose information for AECL NEWs and corrections of the mistakes discovered during data processing. This corrected cohort was named the “expanded cohort.”

Reanalysis Main Findings

- Approximately 42,200 NEWs from Hydro-Québec, New Brunswick Power Corporation, Ontario Hydro, and AECL, first employed since 1965, had no increase in risk of solid cancer mortality due to their occupational radiation exposures.
- A group of 3,088 AECL NEWs first employed before 1965 (1956-1964) was the only group of workers with a consistent radiation-associated increase in risk of solid cancer mortality. The risk estimate was statistically significant and was nine times higher than the risk estimates for those with zero dose. This group of AECL NEWs had a profound impact on the Canadian and 15-country study findings. This group of workers also had significantly higher average whole-body doses compared to workers employed at a later time or in other facilities.
- It is very likely that these early AECL NEWs have incomplete dose information (i.e., their doses are under-reported).
- Despite this apparent increase in cancer risk, a comparison using the Canadian Mortality Database showed statistically significant lower rates of all causes of death and cancer mortality for this group than for the general Canadian population
- Further investigation of this group of early AECL NEWs is necessary to ensure the accuracy and completeness of radiation dose records in the NDR.

Possible Ways to Improve the Data

The data review and correction performed for this reanalysis suggests that there are still outstanding issues with the dose records for early AECL NEWs. Staff of the CNSC, AECL and the NDR are working together to better understand the issues and to correct dose records. It is anticipated that the dose data for early AECL NEWs in the NDR will be resolved in the near future.

Once the integrity of the dose data in the NDR for these early AECL NEWs has been ascertained, the CNSC will undertake a follow-up epidemiological study of Canadian NEWs in order to shed light on the nature of cancer risks observed among AECL NEWs and to produce more accurate cancer risk estimates from exposure to low doses of ionizing radiation for the entire Canadian NEWs cohort.

CONCLUSIONS

- The CNSC's reanalysis confirms that there is no increase in risk of solid cancer mortality among any Canadian nuclear power plant workers for any time period or for AECL NEWs first employed since 1965.
- While the data suggests an increased solid cancer mortality risk for AECL NEWs first employed before 1965 (1956 to 1964), a comparison using the Canadian Mortality Database showed lower rates of all causes of death and cancer mortality for this group than for the general Canadian population.
- The CNSC does not have confidence in the historical dose data for AECL before 1965 (1956 to 1964). The apparent increase in the risk of solid cancer mortality for these early AECL NEWs deserves further investigation.

The findings of this reanalysis are in alignment with the findings of previous studies conducted in Canada and internationally. Specifically, NEWs employed at all Canadian NPPs and at AECL since 1965 do not have an increased risk of solid cancer mortality. Incomplete dose records are likely the cause for the apparent increased risk of solid cancer mortality in AECL NEWs first employed before 1965 (1956-1964).

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