Patterns of mortality and cancer incidence among adults who live near Canadian nuclear power plants

Presentation to Durham Nuclear Health Committee (DNHC)

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Presented by

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Presenters

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Motivation for study

- Ionizing radiation is a carcinogen, and it has been studied in several highly exposed occupational groups
- Some research suggests it increases the risk for non-cancer health outcomes
- In the early 1980's, there were reports of increased risk of childhood leukaemia around the nuclear fuel reprocessing plant at Sellafield in the UK
- Studies by the UK Committee on Medical Aspects of Radiation in the Environment (COMARE, e.g., concluded that
  "… there is no evidence to support the view that there is an increased risk of childhood leukaemia and other cancers in the vicinity of NPPs in Great Britain (e.g., COMARE14threport.pdf)"
- Since then, there have been a number of ecological studies reported in the peer reviewed literature

Motivation for study cont'd

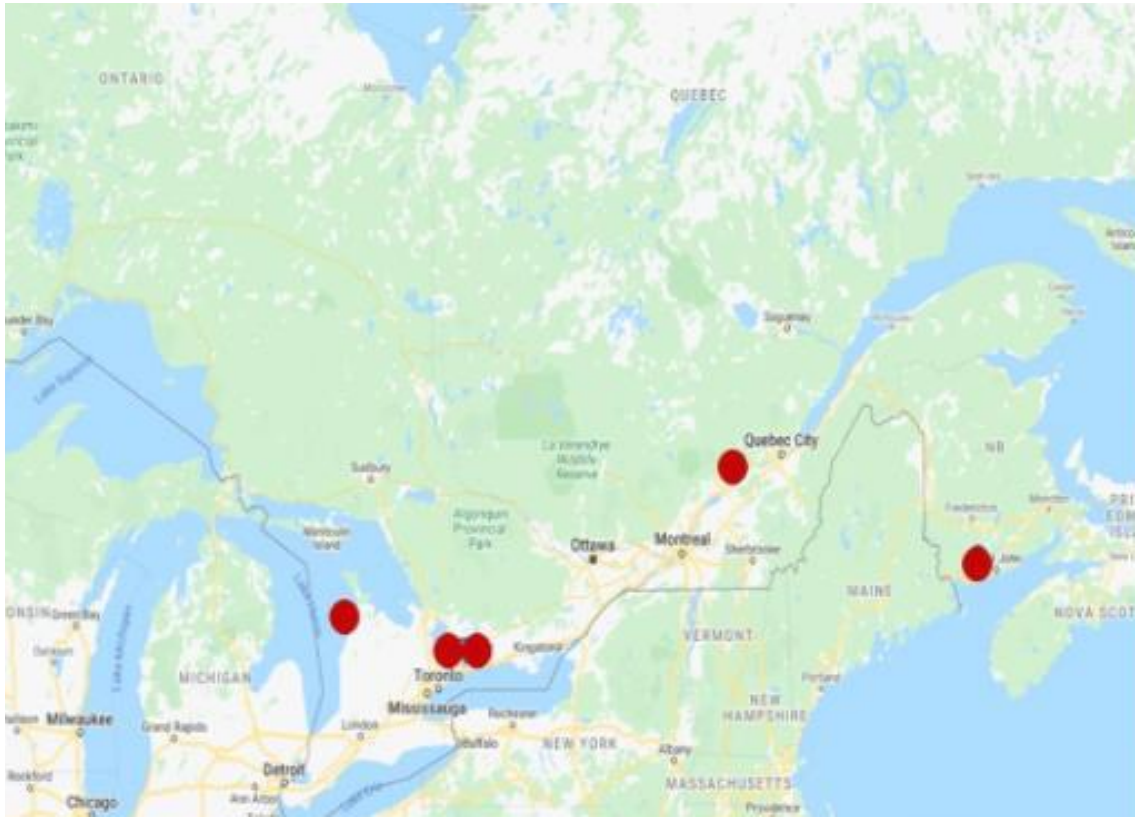
- Several ecological studies have been performed around Ontario nuclear Power Plants in Durham
  - McLaughlin et.al (1989,1991, 1993)
  - Durham Region Health Department (2007), and
  - Lane et.al., (2013)
- Cohort studies are the 'Gold standard"
  - In cohort studies a group of people some of whom have the disease of interest are followed through time, some of whom are exposed and some of whom are not exposed.
  - They include individual-level data on health outcomes and other risk factors
- A 2013 paper by Suthritha et al (Dr Petrusiak was an investigator)
  - Used a retrospective cohort approach to study whether tritium from the Pickering NGS was associated with a risk of cancer in Pickering residents
  - The authors used a linkage (1985) of Pickering and North Oshawa residents(control) to cancer incidence (1985 to 2005) and estimates of exposures to tritium based on location.
  - External cohort comparisons using SIRs were made

CIHR Nuclear Power Plant Study

- 5 year study (2020-2024)
- Population-based cohort study assembled from Canadian long form censuses (1991 through 2011)
- National ascertainment of death and cancer incidence data
- Follows individual activities (including residential mobility)
- Place of residence captured at 6 character postal code
- Individual dose estimates

Canadian Nuclear Power Plants

- There are 5 Nuclear Power Plants
  - 22 nuclear reactors
  - ~ 15% of Canadian Electricity
- Technical experts and onsite inspectors to ensure that rigorous oversight of plant operation is maintained, in order to protect the public and the environment.
- Operating facilities and the communities:
  - Bruce Nuclear Generating Station (ON)
  - Pickering Nuclear Generating Station (ON)
  - Darlington Nuclear Generating Station (ON)
  - Gentilly-2 Nuclear Facility (QC)
  - Point Lepreau Generating Station (NB)
- From population perspective, samples sizes are small outside of Ontario



Population estimates around the five Canadian Nuclear Power Plants, by selected buffer distances, based on 2001 census data

Nuclear Power Plant	Distance buffer	Population	Female	Male	Median Income ($)
Bruce (Ontario)	5 km	0	0	0	0
	10 km	1,870	930	950	41,612
	15 km	4,205	2,070	2,145	44,047
	25 km	22,380	11,530	10,850	49,712
Pickering (Ontario)	5 km	65,120	33,415	31,665	73,642
	10 km	211,025	107,540	103,395	78,210
	15 km	438,030	224,680	213,145	68,792
	25 km	1,475,455	761,120	714,285	62,780
Darlington (Ontario)	5 km	6,930	3475	3,455	73,487
	10 km	78,145	39,620	38,490	62,865
	15 km	196,910	100,395	96,410	63,207
	25 km	338,000	172,065	165,880	65,138
Gentilly – 2 (Quebec)	5 km	0	0	0	0
	10 km	2,475	1,240	1,230	25,242
	15 km	44,205	22,800	21,330	29,713
	25 km	145,635	75,795	69,720	34,931
Point Lepreau (New Brunswick)	5 km	0	0	0	0
	10 km	365	180	185	20,343
	15 km	1,590	775	815	36,857
	25 km	6,105	3,060	3040	40,052
Combined	5 km	72,050	36,890	35,120	
	10 km	293,880	149,510	144,250	
	15 km	684,940	350,720	333,845	
	25 km	1,987,575	1,023,570	963,775	

* To adhere to Statistics Canada's disclosure rules, the population counts were randomly rounded by base of 5 units; as a result, some sums (males + females) may differ from totals

Research Objectives (I)

Overarching Research Objective

- To determine whether individuals who live in the vicinity of NPPs have different rates of mortality and cancer incidence relative to those who do not.

Specific objectives

1. To characterize temporal and spatial variations in exposure to ionizing radiation around the 5 Canadian Nuclear Power Plants between 1991 and 2016.
2. To determine the associations between residentially-based estimates of ionizing radiation and **specific types of cancers**. This will be done using two approaches:
    i. Comparison of cancer incidence rates between those living close to the nuclear power plants to those who do not
    ii. Estimating the cancer risks in relation to spatiotemporally defined measures of exposure created for each nuclear power plant

- Cancers of interest: leukemia, multiple myeloma, and cancers of the thyroid, bladder, breast, lung, ovarian, colon (excluding rectum), stomach, liver and esophagus.

Research Objectives (II)

Specific objectives (continued):

3. To determine the associations between residentially based estimates of ionizing radiation and **cause-specific mortality** specifically for: non-accidental, cancer, cardiovascular and neurological deaths.
4. To estimate the impact on anthropogenic radiation exposure on overall life expectancy among those who live in proximity to NPPs
5. To estimate the extent to which these associations between radiation and health outcomes (cancer and mortality) vary by biological sex (at birth), age-group, and length of residency.

CanCHEC Cohorts

- We would investigate the research objectives by using individual-level data from a Canadian population-based cohort.
- We will use the Canadian Census Health & Environment Cohorts (CanCHEC), comprising 22.4 million adult records our analyses will use 13.4 million uniquely defined adults.
- Use the long form census data from 1991, 1996, 2001, 2006, 2011
- Follow-up for cancer incidence and mortality through 2016

Covariates from CanCHEC

- Individual data on:
  - job title, annual household income, family size, age, sex, ethnicity, household,attained education, and ethnicity.
- Contextual (neighbourhood data also available):
  - Can-MARG, median income, % immigrants, education, lone parent households, urbanicity, etc
- Missing key variables:
  - Smoking, obesity, etc - methods of indirect adjustment

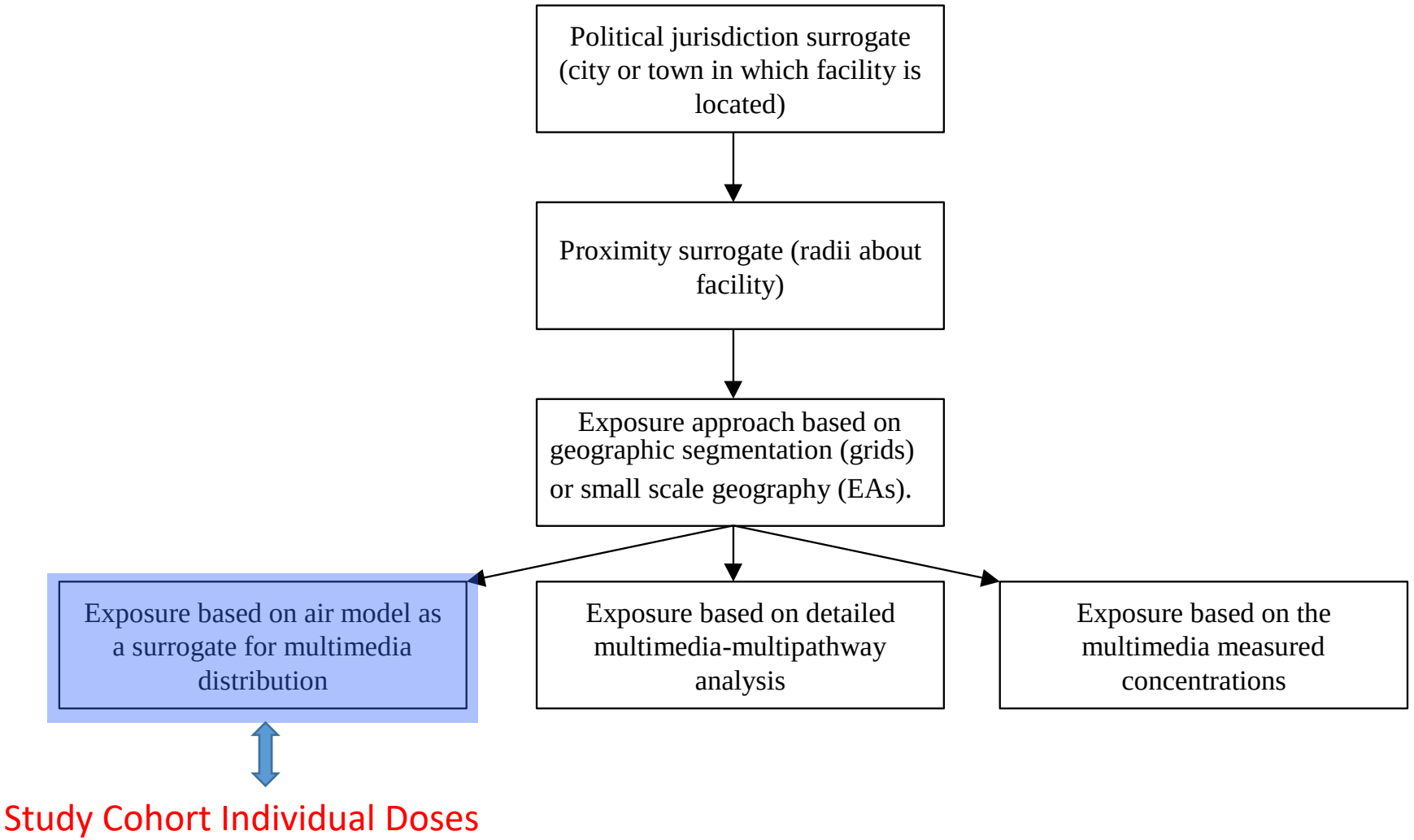
Exposure characterization

- All NPP have extensive emissions monitoring and reporting
- All NPP have annual dose assessments and reporting
- HC provides additional monitoring of radioactivity and background levels
- The CNSC regulates and closely monitors the NPP and has their own environmental monitoring (as a check/audit)
- The CSA has developed regulatory guides for operation of nuclear station, among them,
  - *N288.0-14, Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*

Radioactive releases from NPPs

- The routine emissions of radioactivity to air and water are well documented
  - Tritium
  - Noble gases
  - Iodine 131
  - Carbon-14
  - Particulate

Exposure Approach Hierarchy



Timelines

- 5 year study
- Year 1
  - Ethics permission
  - Statistics Canada permission
  - Begin developing exposure surfaces
- Year 2-5
  - Analysis
  - Papers
  - Knowledge translation activities

Trainees

- We requested funds to support 6 trainees
- 2 PhD trainees and 3 at the MSc level, and 1 postdoctoral fellow.
- Spread amongst the participating universities
- Breakdown:
  - Developing exposure surfaces (Dr. Daniel Rainham – Dalhousie UNiversity)
  - Cancer incidence outcomes
  - Mortality outcomes
  - Risk communications (Dr. Cheryl Peters – University of Calgary)

* Also have funds for a research coordinator (50% role) for the full five years of the study

Next steps

- Permissions from Statistics Canada to access data
- Recruitment of students – priority for a GIS student
- Begin to work on exposure surfaces
  - Input from Dr. Rachel Lane (CNSC)
  - Also potential input (data) utilities

Materials Referred to in this presentation

- Committee on Medical Aspects of Radiation in the Environment (COMARE) FOURTEENTH REPORT *Further consideration of the incidence of childhood leukaemia around nuclear power plants in Great Britain*. COMARE 14th report (publishing.service.gov.uk)
- Clarke EA, McLaughlin J, Anderson TW. *Childhood leukemia around Canadian nuclear facilities - phase I: final report* [Internet]. Ottawa (ON): Atomic Energy Control Board; 1989 May
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Materials Referred to in this presentation cont'd

- Lane R, Dagher E, Burtt J, Thompson PA. *Radiation exposure and cancer incidence (1990 to 2008) around nuclear power plants in Ontario, Canada*. *J Environ Prot. 2013;4:888–913.* [Google Scholar]

- S. Wanigaratne et.al, *Estimating cancer risk in relation to tritium exposure from routine operation of a nuclear-generating station in Pickering, Ontario*. Vol 33, No 4, September 2013 – Chronic Diseases and Injuries in Canada

- SENES. *AIR DISPERSION Modelling in Support of the Ontario Health and Environment Integrated Surveillance (OHEIS) Project* . Prepared for Cancer Care Ontario 2009, March.