Dalla Lana
School of Public Health

Prospective cohort studies in Canada and their role in assessing environmental risk factors

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For OEH Seminar, Toronto
January 10, 2020

UNIVERSITY OF TORONTO
DALLA LANA SCHOOL OF PUBLIC HEALTH

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Disclosure of Conflicts of Interest

None

Declaration:

- *Professor McLaughlin is co-lead of program with funding awarded through a national competition to establish the scientific base for the Canadian Partnership for Tomorrow Project*

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Outline

1. Environmental epidemiology examples and designs
2. Cohort study history & Canadian opportunities
3. Canadian Partnership for Tomorrow Project
   - CPTP purpose, design & current status
4. CPTP for studies of environmental factors
5. CPTP partnerships and unique opportunities
6. Future directions and discussion

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Environmental & Genetic Factors in Lung Cancer

American Journal of Epidemiology
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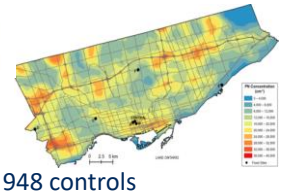
Vol. 179, No. 4
DOI: 10.1093/aje/ket289
Advance Access publication: November 27, 2013

A Case-Control Study of Long-Term Exposure to Ambient Volatile Organic Compounds and Lung Cancer in Toronto, Ontario, Canada

Paul J. Villeneuve*, Michael Jerrett, Darren Brenner, Jason Su, Hong Chen, and John R. McLaughlin



Toronto-based case-control study: 445 cases & 948 controls

Results: Benzene - OR=1.8 (95% CI = 1.3 - 2.7) Nitrogen dioxide - OR=1.6 (95% CI = 1.2 - 2.1)

Environmental Factors			**Genetic Factors**		
24 publications			**21** publications		
Synergy Consortium – 5K cases + 6.5k controls			ILCCO Consortium – 12K cases + 15k controls		
Exposure	OR (95% CI)	Pub	Gene	OR (95% CI)	Pub
eg, ETS	1.4 (0.9-2.2)	Kim et al, Int J Ca 2014	eg, 15q25	1.2 (1.1-1.3)	Hung et al, Nature 2009

Consider:

- *Strength of association & causality?*
- *Modifiable risk factor?*
- *Effective intervention?*
- *Implementation & by whom?*

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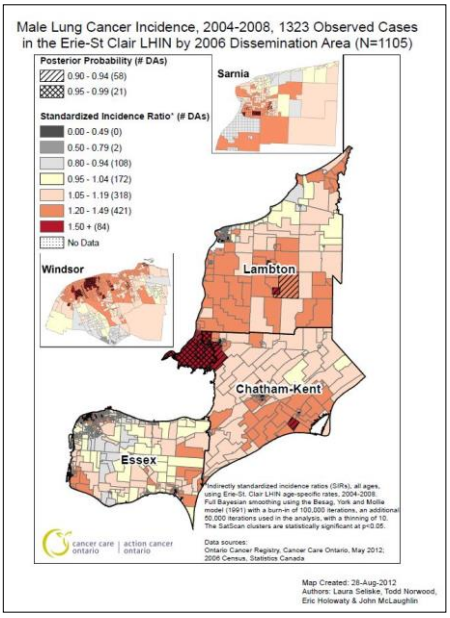
Cancer Registry Data - Ontario Population (cohort)



Lung Cancer Standardized Incidence Ratios

– Advanced GIS analysis with Bayesian smoothing & covariate adjustment

Geospatial Analysis Project
(Cancer Research Society grant to McLaughlin, Holowaty, Norwood & Harris)

Population data resources for exposures & outcomes enable environmental studies

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Previously presented - Cross-Canada Case-Control Study - An early report on Glyphosate

[published odds ratio (OR), relative risk (RR) and confidence interval (CI)]

McDuffie et al. (2001), Cancer Epidemiol Biomarkers Prev 10:1155

- Recall of pesticide exposures in early-1990s and before
- 4 types of cancer & many pesticides
- Prior hypothesis re: NHL and Phenoxy-herbicides (e.g., 2,4-D)
- Number who ever used glyphosate

  Cases = 51/517 (10%) vs. Controls = 133/1506 (9%)
- **Ever used glyphosate - OR = 1.2 (95% CI = 0.8-1.7)** (adjusted*)
- **Longest use of glyphosate - OR = 2.1 (95% CI = 1.2-3.7)***

** Logistic regression model adjusted for age, province, medical risk factors (e.g., measles, mumps, family history, etc.)*

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Study Design Options – e.g., NHL

Non-Hodgkin Lymphoma

- Annual Incidence rate = 20 per 100,000 (age-standardized, both sexes combined / Source: Canadian Cancer Statistics, 2016)
- Rare disease

How large a cohort needed to obtain 500 incident cases ?

- Cohort size (approximately)
  = No. cases / Rate (cases per 100,000 persons per year)
  = 2,500,000 p-yrs (i.e., follow 100,000 for 25 yrs)
- Whereas our case-control study collected information on approximately 2,000 participants

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Interpretation of Glyphosate Results from Case-control vs. Cohort Studies

Study	OR	*# Cases*	Exposure Assessment
Case-Control - NHL			All used self-report
- McDuffie 2001	2.1 (1.2-3.7)	***517 (51 exposed)***	
- De Roos 2003	2.1 (1.1-4.0)	872	Validation with no evidence of recall bias *
- Eriksson 2008	2.0 (1.1–3.7)	910	
Cohort			Self-report, with validation in sub-study
- *De Roos 2005*	1.1 (0.7-1.9)	***92 NHL (71 exposed)***	
	2.6 (0.7-9.4)	32 Multiple Myeloma	

* - Blair and Zahm. Epidemiology. 1993; 4:55–62.

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Radiation & Breast Cancer – *A cohort example*

Canadian Fluoroscopy Cohort Study

- Howe and McLaughlin. Radiation Research 1996

- 31,917 women
- treated for TB in Canadian institution between 1930-52
- 688 breast cancer deaths from 1950 to 1987
- Excess RR approximately constant from 5 to 39 yrs after exposure, with a possible decrease between 40 and 57 yrs
- Model estimates excess lifetime risk of breast cancer mortality after repeated, low-dose radiation exposures
- Relevant to risk assessment for routine mammographic screening

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Cohort study history & Canadian opportunities

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Prospective Cohort Studies – *A selective history*

- Frost (1935) introduced "cohort study" in 1935 to study TB in people born at different periods
- Framingham Heart Study – n = 5200 recruited in 1948-52, with 65 year follow-up and >3000 publications (Dawber et al)
  - Including odds ratio and early us of logit, leading to logistic regression (Cornfield 1951)
- Doll and Hill (1954) published 1st mortality follow-up from British Doctors Study – n=40,000 recruited in 1951 and followed for 50 years (Doll et al 2004)
  - Assessing environmental risk factors – e.g., Doll and Peto (1954) re: smoking

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Prospective Cohort Studies in Canada

- a brief historical selection

- Computerized record linkage (Newcombe, Science 1959)
- Many cohort eg's across Canada – by population stratum, age (birth, older ages), occupation, geographic, ethno-cultural, disease-status, etc.
- Canadian Fluoroscopy Study – 120,000 adults fluoroscoped for TB therapy from 1930-52 with 60+ yr follow-up - linked to mortality and cancer incidence (Miller et al.)
- Canadian National Breast Screening Cohort Study (NBSS) – 90,000 women in RCT of breast cancer screening, ages 40–59 between 1980-85, 30 yr follow-up by record linkage (Miller et al.)

Anthony Miller
Professor Emeritus, DLSPH
and ***Order of Canada! (Dec. 2019)***

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Canadian Partnership for Tomorrow Project (CPTP) - Purpose, design & current status

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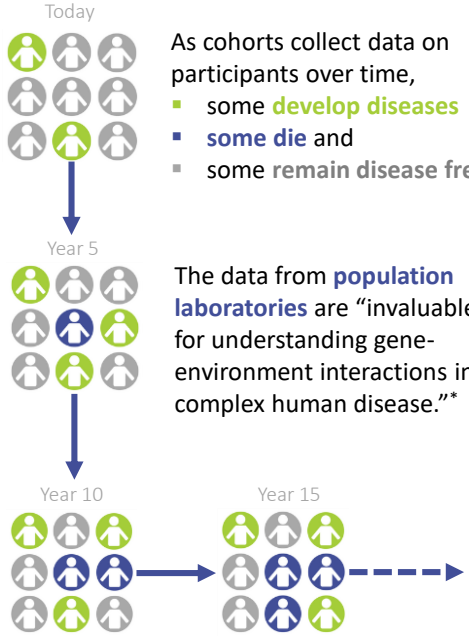
Large-scale population health observatories enable **detection of disease risks**



As cohorts collect data on participants over time,

- some **develop diseases**
- **some die** and
- some **remain disease free**

The data from **population laboratories** are "invaluable for understanding gene-environment interactions in complex human disease."*

*** Source**:
Maniolo et al. 2006 . *Genes, environment and the value of prospective cohort studies.*

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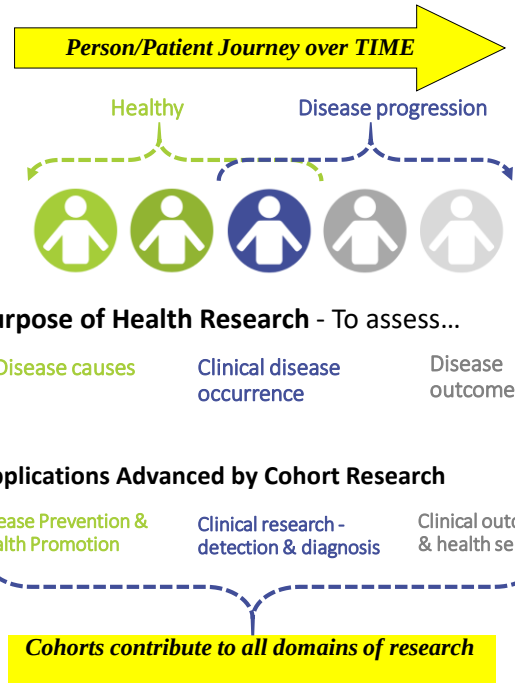
Cohorts contribute across the patient journey, delivering advances ranging from …
– health promotion and disease prevention
- to diagnosis and late outcomes



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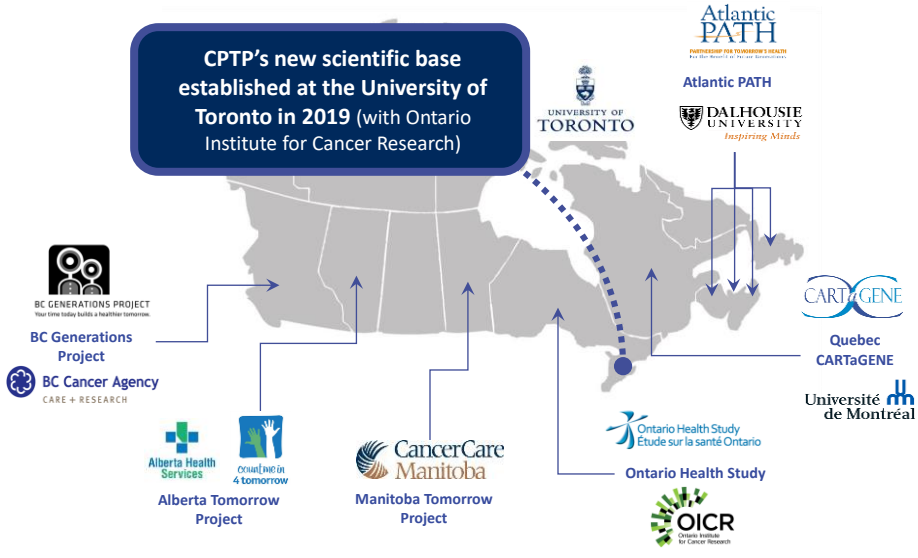
CPTP - A confederation of 6 regional cohorts

(covering 9 provinces, with final province in progress)



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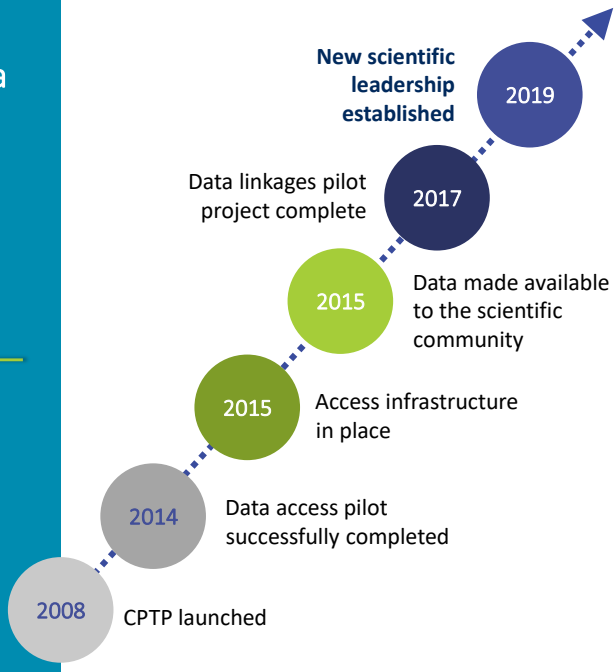
Entering a new era of scientific productivity, leadership, partnership, collaboration and productivity



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CPTP's leadership brings extensive experience in building large-scale research initiatives

- Build on & strengthen established structures
- Strong scientific and operational leadership
- Build on existing partnership
- Designed to strategically attract new partners

Dr. John McLaughlin
Executive Director

Dr. Philip Awadalla
Scientific Director

Experienced in building and sustaining major research platforms used by researchers across Canada, including CPTP.

- Leadership Team:

- *Dr. Trevor Dummer, National Scientific Co-Director at UBC - with all Regional Directors*

***- Operational leads** - across Canada*

- National Strategic Advisory Council** – with **Funders** and **Hosts

- International Scientific Advisory Board

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CPTP Purpose, Vision and Mission

Purpose: Enhance and accelerate research to prevent disease for a healthier Canada.

Vision: Improve population health through a better understanding of the causes of chronic disease and cancer.

Mission: To provide a national platform that supports high quality, innovative population health research in Canada and globally.

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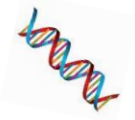
CPTP Data and Biosamples: Beginning in 2008


Core questionnaire	DNA containing samples	Physical measures	Urine samples	Toenail clippings
• >300,000 • Demographics • Lifestyle • Risk factors • Several others	• Venous blood collection (>150,000) • Blood spots (>28,000) • Saliva (>8,000)	• Up to 90,000 • Height/weight • Waist/hip circumference • BMI • Grip strength	• 101,000	• >30,000

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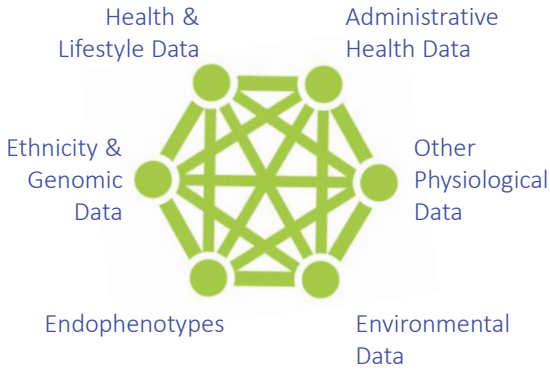
Enabling diverse health research based on linked data

- e.g.

- causes of illness
- outcomes of disease
- response to clinical interventions
- community interventions
- detection of health related inequities
- health systems performance
- etc.

CPTP is **linking personal, behavioural, environmental, health system and biological data** to investigate cancer and chronic disease causes and determinants.



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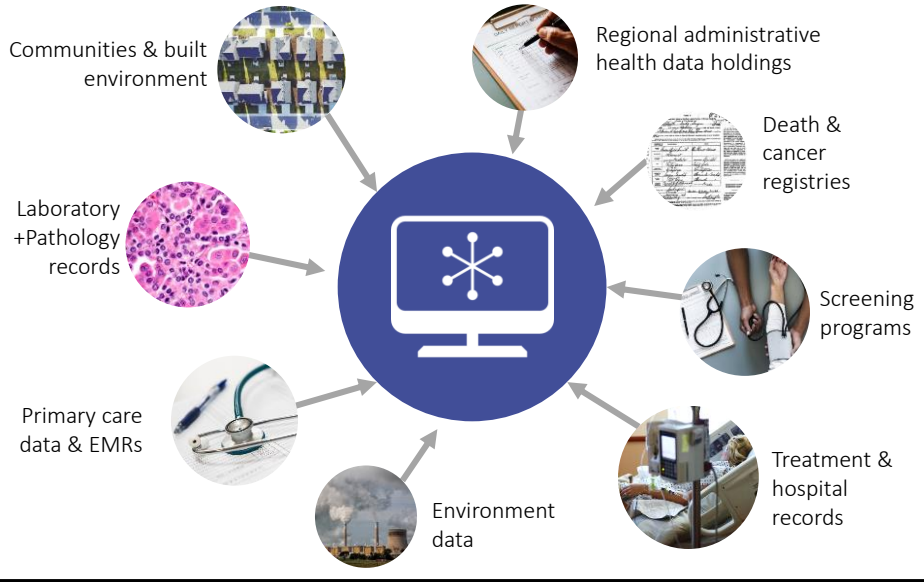
Linking to health data – A distinct Canadian advantage



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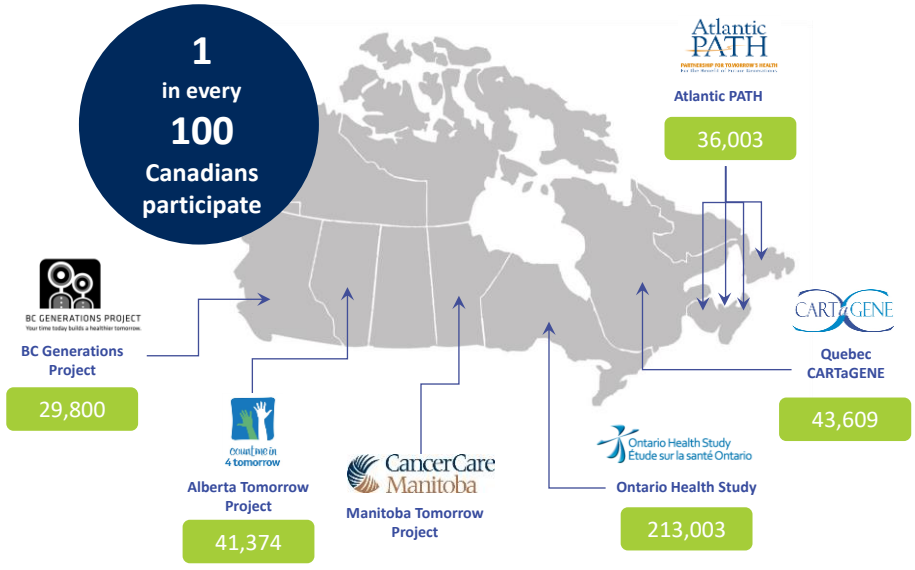
An Active Partnership with Canadians:
Recruited more than 320,000 participants (ages 30-74)



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Summary of CPTP participants and data available for research

T Dummer et al.

CMAJ, June 2018

The Canadian Partnership for Tomorrow Project: a pan-Canadian platform for research on chronic disease prevention

Trevor J.B. Dummer PhD, Philip Awadalla PhD, Catherine Boileau PhD, Camille Craig MSc, Isabel Fortier PhD, Vivek Goel MD, Jason M.T. Hicks MSc, Sébastien Jacquemont MD, Bartha Maria Knoppers PhD, Nhu Le PhD, Treena McDonald MSc, John McLaughlin PhD, Anne-Marie Mes-Masson PhD, Anne-Monique Nuyt MD, Lyle J. Palmer PhD, Louise Parker PhD, Mark Purdue PhD, Paula J. Robson PhD, John J. Spinelli PhD, David Thompson MSc, Jennifer Vena PhD, Ma'n Zawati LLM; with the CPTP Regional Cohort Consortium*

Cite as: *CMAJ* 2018 June 11;190:E710-7. doi: 10.1503/cmaj.170292

Table 2: Distribution of participants in the Canadian Partnership for Tomorrow Project by parent regional cohort

	Participants, no. (%)			
Region	Men	Women	Total	Provided venous blood sample
Atlantic PATH	10 185 (30.4)	23 344 (69.6)	33 529	23 897 (71.3)
CARTaGENE	18 995 (44.8)	23 438 (55.2)	42 433	29 874 (70.4)
Ontario Health Study	66 172 (40.5)	97 291 (59.5)	163 463	41 085 (25.1)
Alberta's Tomorrow Project	13 433 (34.6)	25 351 (65.4)	38 784	29 193 (75.3)
BC Generations Project	9028 (31.3)	19 780 (68.7)	28 808	26 562 (92.2)
CPTP total	117 813 (38.4)	189 204 (61.6)	307 017	150 611 (49.1)

Note: CPTP = Canadian Partnership for Tomorrow Project, PATH = Partnership for Tomorrow's Health.

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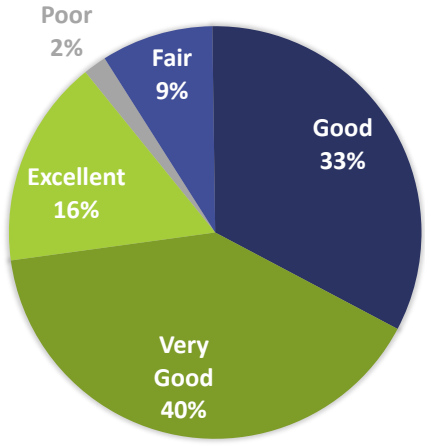
CPTP follows both healthy and affected participants over time
(i.e., prevalent & incident disease)

Overall perception of health status in the CPTP cohort



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Enriching the CPTP Datasets

Derived Data	Questionnaires	3rd Party Data Linkage
• Genotype (fall 2018) • Blood Analyte Data (fall 2018)	• CPTP core follow-up questionnaire • Occupational History Questionnaire	• Canadian Urban Environmental Health Research Consortium (CANUE) (fall 2018) • Cardiac, Vascular and Cognitive Dysfunction Alliance (CVCD Alliance) (spring 2019)

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Access to CPTP Data by the Research Community

CPTP Data Portal –Online and Active

Website: www.partnershipfortomorrow.ca

Portal: portal.partnershipfortomorrow.ca

Facebook: www.facebook.com/cptproject

Twitter: @cptproject

portal.partnershipfortomorrow.ca

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CPTP for OEH research on environmental determinants of disease

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Supporting studies of concern to local populations

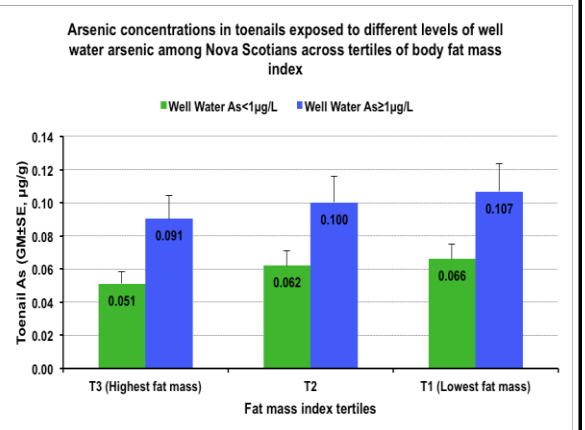
Arsenic and Health (Atlantic)

ORIGINAL ARTICLE

Relationship between drinking water and toenail arsenic concentrations among a cohort of Nova Scotians

Zhijie M. Yu[1], Trevor J.B. Dummer[1], Aimee Adams[2], John D. Murimboh[2] and Louise Parker[1]

Journal of Exposure Science and Environmental Epidemiology advance online publication, 25 December 2013



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Advancing evidence and knowledge translation **relevant to local populations**

Arsenic and Cancer (Atlantic)

Environment International
Volume 66, May 2014, Pages 115-123

What is the role of obesity in the aetiology of arsenic-related disease?

Zhijie M. Yu [a], Bryan Fung [b], John D. Murimboh [b], Louise Parker [a], Trevor J.B. Dummer [a]

Highlights

- An obesity-related diet score was developed using reduced rank regression
- Drinking water arsenic levels were comparable across quartiles of the diet score
- Individuals with obesity-related diets had lower toenail arsenic concentrations

Science of The Total Environment
Volume 505, 1 February 2015, Pages 1259-1273

Understanding the translation of scientific knowledge about arsenic risk exposure among private well water users in Nova Scotia

Heather Chappells [a], Norma Campbell [a], John Drage [b], Conrad V. Fernandez [c], Louise Parker [a], Trevor J.B. Dummer [a]

Highlights

- Scientific and public knowledge of arsenic risk in private wells is misaligned.
- Well users surveyed were confident in water quality without regular testing.
- Local and social networks are key to arsenic risk knowledge circulation.
- Stakeholder interaction highlights effective channels for risk communication.

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CPTP Partnership:

Canadian Urban Environmental Health Research Consortium

Funded as CIHR Signature Initiative ($4M over 5 years)

Environmental data linked to CPTP

CANUE is led by :

- **Dr. Jeffrey Brook** (PI)
- With CPTP leaders and inter-disciplinary, pan-Canadian team of research leaders and collaborators

- Every location in Canada described by complex set of environmental factors
- CANUE is building capacity to study how these multiple **environmental factors are linked to a wide range of health outcomes**
- Enable effective, evidence-based strategies for planning healthy cities and towns, today and in the future.

CANUE

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CANUE Data Platform – Data Themes

CANUE

ANALYSIS-READY EXPOSURE DATA = easy for researchers to access and use

Source *(with thanks): J. Brooks, D. Doiron, E. Seaton*

Canadian Urban Environmental Health Research Consortium 33

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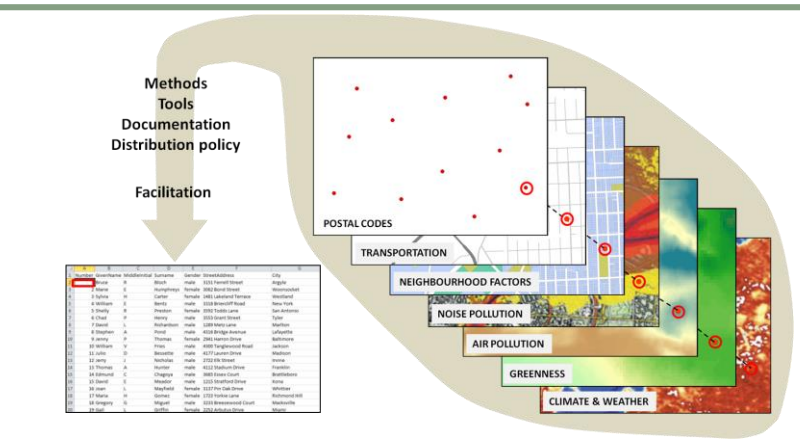
CPTP and CANUE



***Source** (with thanks): J. Brooks, D. Doiron, E. Seaton*

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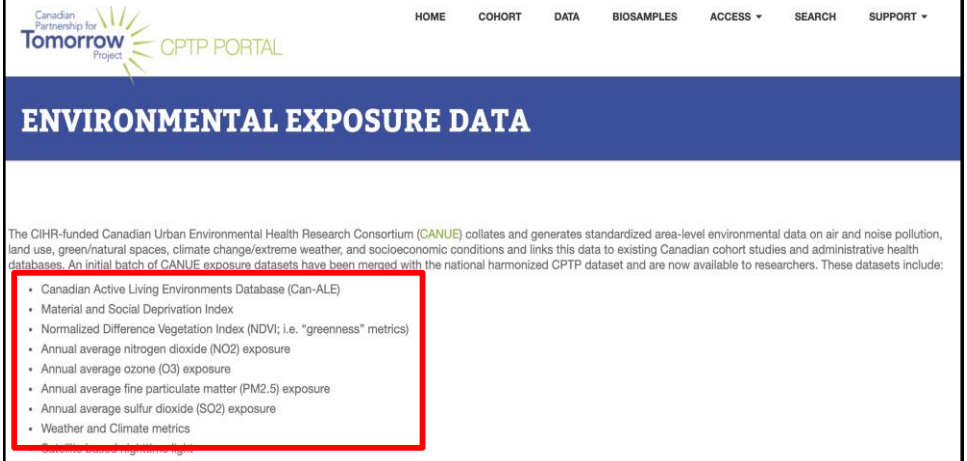
CANUE Data Linked to National CPTP Dataset

https://portal.partnershipfortomorrow.ca/



***Source** (with thanks): J. Brooks, D. Doiron, E. Seaton*

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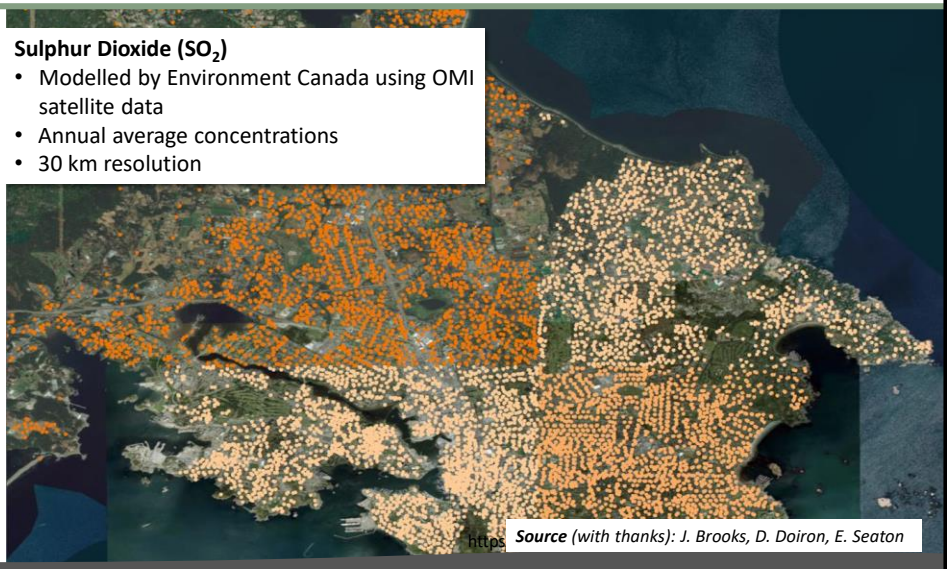
CANUE Data Example – Air quality

Sulphur Dioxide (SO_2)
- Modelled by Environment Canada using OMI satellite data
- Annual average concentrations
- 30 km resolution



***Source** (with thanks): J. Brooks, D. Doiron, E. Seaton*

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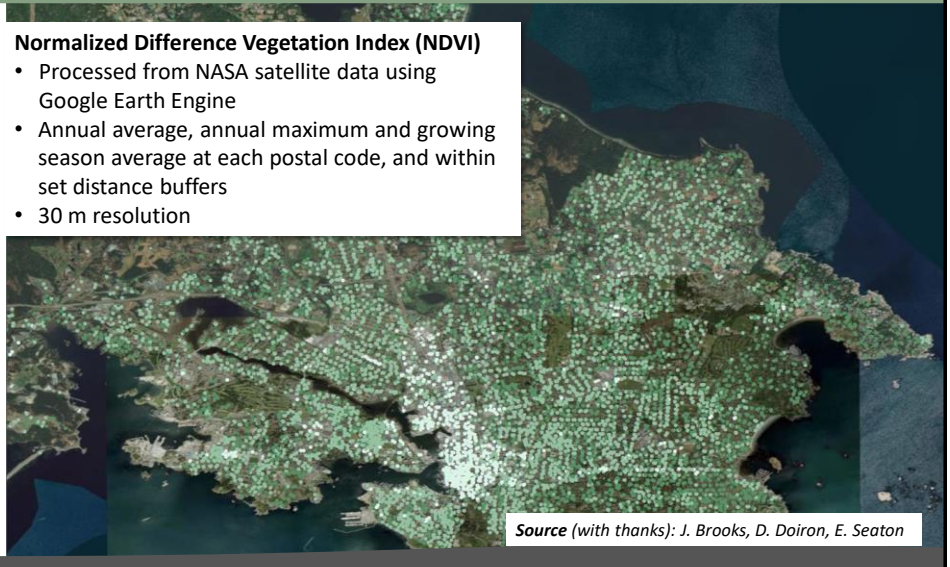
CANUE Data Example – Greenness

Normalized Difference Vegetation Index (NDVI)
- Processed from NASA satellite data using Google Earth Engine
- Annual average, annual maximum and growing season average at each postal code, and within set distance buffers
- 30 m resolution



***Source** (with thanks): J. Brooks, D. Doiron, E. Seaton*

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CPTP Quintile distribution (preliminary data; n = ~250 000)

Quintile thresholds based on exposure data for all Canadian postal codes

CANUE

Variable	Q1	Q2	Q3	Q4	Q5
Material deprivation	69 102 (28.4%)	56 578 (23.2%)	48 992 (20.1%)	40 712 (16.7%)	28 094 (11.5%)
Social deprivation	50 494 (20.7%)	49 717 (20.4%)	47 873 (19.7%)	48 163 (19.8%)	47 231 (19.4%)
Walkability	66 984 (26.7%)	84 445 (33.7%)	63 855 (25.5%)	21 258 (8.5%)	14 317 (5.7%)
NO_2	54 685 (22.4%)	52 760 (21.6%)	46 326 (19.0%)	43 022 (17.6%)	47 187 (19.3%)
SO_2	52 390 (23.2%)	41 642 (18.4%)	46 457 (20.5%)	42 450 (18.8%)	43 286 (19.1%)
O_3	33 942 (13.5%)	28 905 (11.5%)	54 672 (21.7%)	63 227 (25.1%)	70 993 (28.2%)
Greenness (year mean)	41 631 (16.5%)	47 534 (18.9%)	57 504 (22.8%)	56 267 (22.4%)	48 810 (19.4%)

***Source** (with thanks): J. Brooks, D. Doiron, E. Seaton*

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Residential History Construction: Social Data Linkage Environment (SDLE)

CANUE

Statistics Canada Statistique Canada https://www.statcan.gc.ca/eng/sdle/index

Canadian Partnership for Tomorrow Project / Projet de partenariat canadien Espoir pour demain

Individual identifiers and unique id

SDLE

Residential history created and exposure assigned by postal code

CANUE

exposure data by postal code/year

Exposure and unique id

***Source** (with thanks): J. Brooks, D. Doiron, E. Seaton*

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For More Information about CPTP and CANUE:

Jeff Brook
Scientific Director
UNIVERSITY OF TORONTO
DALLA LANA SCHOOL of PUBLIC HEALTH

CPTP National Webinar

- **by Jeff Brook on February 13th at 12:00**
- https://zoom.us/webinar/register/WN_FAo2IfKeSVynLe3noWe6ig

CPTP Website and Data Portal

- https://portal.partnershipfortomorrow.ca

CANUE Website and Data Portal

- https://www.canuedata.ca

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CPTP Partnerships & Unique Opportunities

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Key partnership:

Canadian **Alliance** for Healthy Hearts and Minds (CAHHM)

Funded by CPAC, to advance cardiovascular and cerebrovascular research

Comprehensive clinical and imaging data for a CPTP subset across Canada

Recruitment, assessment, specimen / data collection completed; MRI's completed; Resource being made available for research uses.

- Collected detailed information on vascular disease, cardiac disease and cognitive function using MRI scans
- Data collected from 10,000 Canadians through existing cohorts, including **1500 First Nations people** living in Canada
- Unique data to evaluate the impact of diverse **environmental determinants on cardiovascular health**

The Alliance is co-led by **Drs. Sonia Anand** , Matthias Friedrich and the late Jack Tu.

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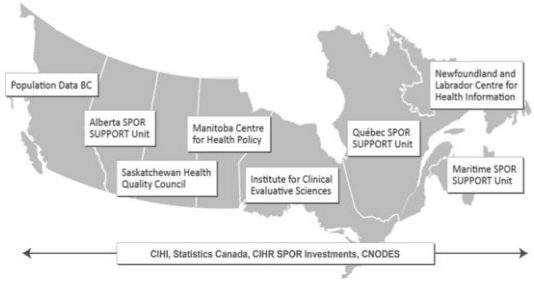
Key partnership:

Pan-Canadian Real-world Health Data Network (PRHDN)

Enable CPTP to access linked health systems data from across Canada

PRHDN **led by K. McGrail (BC), with M. Schull (ICES), national team and with CPTP leaders as co-applicants and end-users**

PRHDN is a distributed data network that allows researchers and policy/decision makers across Canada to use linked and linkable administrative (real-world) **data holdings and expertise in multi-province studies** and initiatives without requiring that data leave provincial boundaries.



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Canadian Population Studies & CPTP`s Unique Stature
(examples)

Cohort studies with comprehensive data and biospecimens:

	N participants
CPTP (Canadian Partnership for Tomorrow Project)	**> 320,000**
CLSA (Canadian Longitudinal Study of Aging)	~ 50,000
MIREC (Maternal Infant Research on Environmental Chemicals)	2001
CHILD (Canadian Healthy Infant Longitudinal Development)	3455

Examples of alternative platforms:

Canadian Health Measure Survey (5 cross-sectional surveys)	~ 29,000
Canadian Community Health Survey (X-S survey every 2 yrs)	~ 65,000

Large size essential to assess complexity & rare exposures or outcomes

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CPTP singularly enables Canada to contribute to the network of internationally recognized large-scale initiatives

CPTP is an **internationally recognized large-scale initiative** (100,000+ participants) working with other large cohorts around the world, including:

- Biobank Japan
- China Kadoorie Biobank
- **Canadian Partnership for Tomorrow Project (CPTP)**
- EPIC
- Kaiser Permanente Research Program
- LifeGene
- Million Veteran Program
- Million Women Study
- Multiethnic Cohort Study
- MyCode Community Health Initiative
- Nurses' Health Study (NHS/NHSII)
- US Precision Medicine Initiative/ All of Us
- Tohoku Medical Megabank Project

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Future Directions and Discussion

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CPTP Innovations for Occupational Epidemiology

Evaluation of AI algorithm to Classify Occupational History (2019-20)

- PI - Dr. Ellen Sweeney, Director of Strategic Research Initiatives, Atlantic PATH
- Interdisciplinary team conducting project to enhance CPTP's data platform
- Aim – to improve data quality by harmonizing data of Atlantic Path's and Alberta's Tomorrow Project's 111,000 occupational history questionnaires
- Automatic Semantic Occupational Coding algorithm (Bao, Baker, Adisesh) to analyze and harmonize open-text data, occupational history information across two cohorts, and evaluated for utility in other regions.

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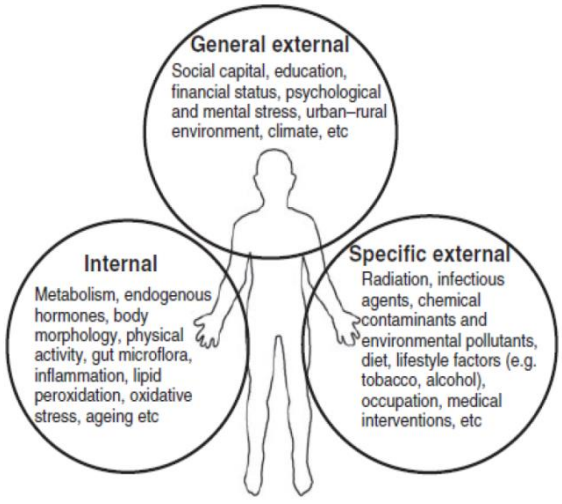
The **Exposome** - Three Domains of Environmental Exposures (with examples)



Source: C Wild. Int J Epidemiology 2012; 41: 24.

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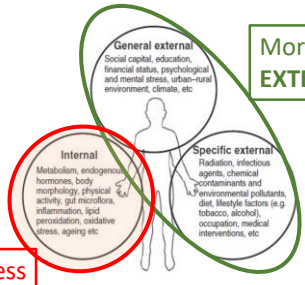
Exposomics (Internal) & Detection of Biological Response



More traditional measures of **EXTERNAL** environment

New possibilities to assess **INTERNAL** environment & biological response

- High throughput ``genomics`` tools to characterize:
  - Genome – Transcriptome – Proteome – Metabolome …
  - Characterize gene-environment interactions
  - Detect biological effects and susceptibilities

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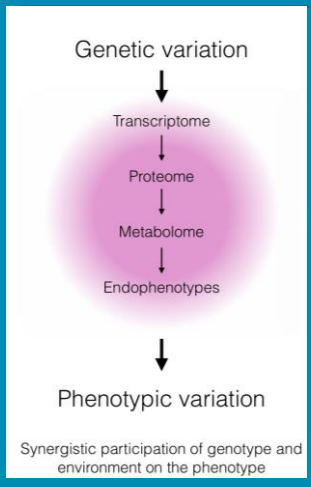
CPTP enables studies of **gene-environment interactions**



Recombination affects accumulation of damaging and disease-associated mutations in human populations

Julie G Hussin, Alan Hodgkinson, Youss
Jean-Philippe Goulet, Elias Gbeha, Eloc

Nature Genetics **47**, 400–404 (2015) |

nature genetics

High-Resolution Genomic Analysis of Human Mitochondrial RNA Sequence Variation

Alan Hodgkinson,[1]* Youssef Idaghdour,[1,2]*† Elias Gbeha,[1] Jean-Christophe Grenier,[1] Elodie Hip-Ki,[1] Vanessa Bruat,[1] Jean-Philippe Goulet,[2] Thibault de Malliard,[1,2] Philip Awadalla[1,2]‡

Mutations in the mitochondrial genome are associ
processes; however, little is known about the exte
transcriptome. By ultra-deeply sequencing mitoch
blood of ~1000 individuals from the CARTaGENE
sequence variation within and across individuals,
of posttranscriptional modification. Using a genor
posttranscriptional modification of functionally im

Science AAAS

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CPTP enables studies of gene-environment interactions, of direct relevance and interest to communities

Gene-by-environment interactions in urban populations modulate risk phenotypes

Marie-Julie Favé, Fabien C. Lamaze, David Soave, Alan Hodgkinson, Héloïse Gauvin, Vanessa Bruat, Jean-Christophe Grenier, Elias Gbeha, Kimberly Skead, Audrey Smargiassi, Markey Johnson, Youssef Idaghdour & Philip Awadalla

Nature Communications **9**, Article number: 827 (2018) | *March 2018*

THE GLOBE AND MAIL

Genetic study of Quebec residents finds air pollution trumps ancestry

"That's really what precision health is about," Dr. Awadalla said. "You want to capture these things before people are in the doctor's office and having to be treated."

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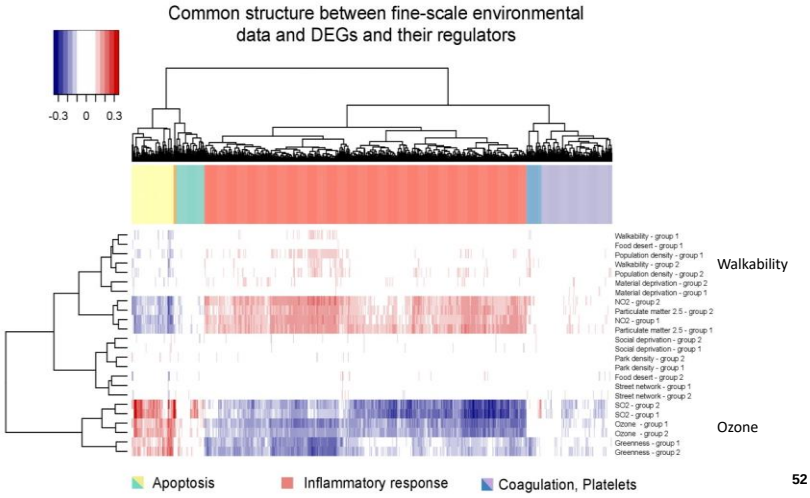
Integrating Internal and External Exposomes

- Epigenomic Assessment of Gene-Environment Patterns in Quebec

Awadalla et al (Nature Comms - 2017) - Differentially expressed genes (DEGs) are associated with local ambient air pollution.



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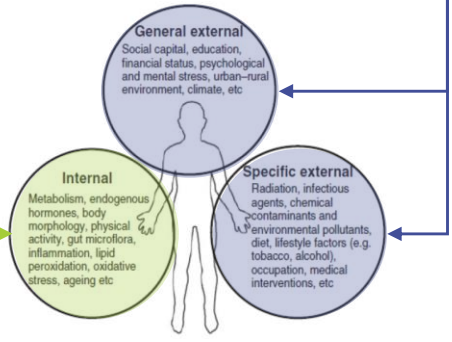
Opportunity for advancing environment and health research in Canada

CANUE – Canada's **external** exposome data for individual-level assessments, with CPTP



New exposomics initiatives

- Complete exposome assessments
- Integration with big health data
- Enhance expertise & advanced analytical methods

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Discussion

CPTP makes "Big Data" and Cohort approachs possible to detect and manage environmental effects on health across Canada.

What could you do with ongoing data on more than 300,000 participants across Canada?

- Analysis of existing data, and collaborations to expand on and enrich data – e.g., advanced exposure assessment, exposomics…
- A platform for your grants, to support analytics and grad students – e.g., CIHR calls for proposals.
- A base and starting point for major initiatives – e.g., as with "Alliance" (CAHHM), CANUE, CFI, New Frontiers…
- Collaborations to resolve gaps and limitations in Canada's population data capacity – e.g., sustained cohort follow-up complements Canada's existing platforms for monitoring, characterizing and managing environmental health effects.

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Canadian Partnership for Tomorrow Project

Thanks to all CPTP participants and supporters across the 6 regional cohorts who generously donate their time, information and biological samples. **CPTP is a success because of participants' ongoing commitment.**

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Canadian Partnership for Tomorrow Project

Thanks to all sponsors and partners – Current & Future, and

Join us at portal.partnershipfortomorrow.ca

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HEART & STROKE FOUNDATION

Alberta Cancer FOUNDATION

ALBERTA INNOVATES

Ontario Cancer Care Ontario

Alberta Health Services

OICR Ontario Institute for Cancer Research

CANADIAN PARTNERSHIP AGAINST CANCER

PARTENARIAT CANADIEN CONTRE LE CANCER

UNIVERSITY OF TORONTO

CIHR IRSC Canadian Institutes of Health Research / Instituts de recherche en santé du Canada

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