Ontario Health Study
Étude sur la santé Ontario

The Ontario Health Study:

A resource for cancer, disease and health research in Ontario and Canada

2025 Northern Health Research Conference

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June 17, 2025

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Disclosures

Affiliations:

I have relationship with the following for-profit or not-for-profit organizations:

Grants/Research Support: Canadian Institutes of Health Research, Public Health Agency of Canada

Other: Employee of the Ontario Institute for Cancer Research

Financial Support:

This session/program hos not received financial or in-kind support.

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Learning Objectives

1. Describe the Ontario Health Study and its real and potential impacts on patient populations in Northern Ontario.
2. Identify opportunities for Northern Ontario research projects to utilize data from the Ontario Health Study.
3. Incorporate OHS Data into research projects.

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What is the Ontario Health Study (OHS)?

The OHS is a **longitudinal cohort study,** where study participants are followed over time via questionnaires, biological samples, and other forms of data collection.

The Study examines how **lifestyle, the environment and genetics** interact to affect people's health.

The OHS makes the data and biosamples of its **225,000 participants** available to researchers investigating cancer and other conditions.

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Enabling research breakthroughs

- enables research across health domains to improve disease **prevention, detection, treatment and health services**
- data and biological samples are available to researchers to study **a wide range of exposures (environment, lifestyle, etc.)** and **outcomes (common chronic disease, rare disease, infectious disease, etc.)**
- enables scientists to perform health-related research **today and for years to come**

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Part of Canada's largest population health research platform

The Ontario Health Study is the largest contributing member of **CanPath**, the Canadian Partnership for Tomorrow's Health.

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An overview of OHS Data Holdings

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What does the OHS have available?

- **~225,000** participants, of which **>181,600** are part of CanPath
- **>188,000** participants linked with administrative databases
- **>40,000** non-fasting blood samples (plasma, serum, RBC, buffy coat)
- **>12,800** physical assessments
- **~12,600** urine samples
- **~3,100** MRIs, cognitive assessments
- **~22,000** participants genotyped
- **>23,600** participants diagnosed with cancer
- Ongoing data and biospecimen collection

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Timeline of data and biospecimen collection

- First pilot participant March 26, 2009
- Baseline Questionnaire 2009-2017
- Blood Collection partnership with LifeLabs 2012-2017
- Follow-up Questionnaire 2016-2019
- Recruitment of new participants ends 2017
- Work History Questionnaire 2019
- COVID-19 Questionnaire 2020
- COVID-19 Antibody Study 2021-2023
- Second Blood Collection 2024-2025
- Second Follow-Up Questionnaire 2024-2025

- **Participant demographics**
- **Health status**
- **Medical history**
- **Prescribed medication**
- **Family health history**
- **Anthropometric measurements**
- **Working status**
- **Household income**
- **Behaviours (sleep, alcohol, tobacco, marijuana use, and e-cigarette use)**

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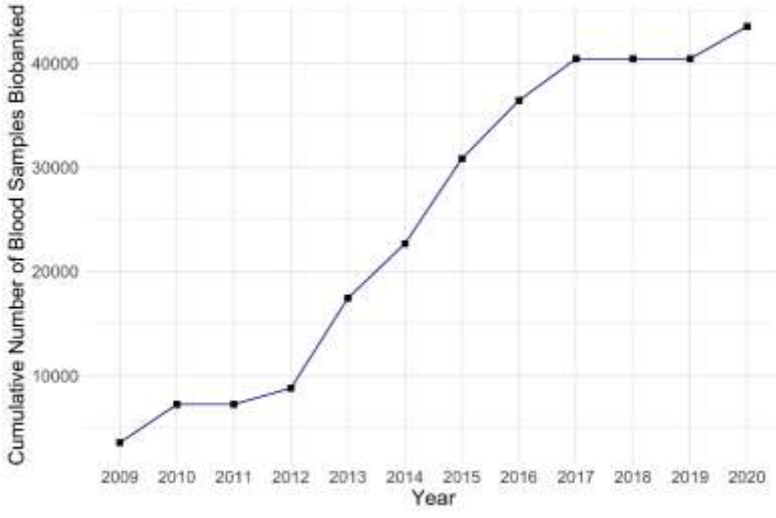
OHS has the largest biobank in Ontario



43,496

Blood samples collected

Most of each blood sample is frozen so that researchers can use some of it in the future

A portion of the blood is used for immediate analysis. These analyses include:

- Complete Blood Count
- Glycosylated Hemoglobin Analysis

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Biosamples and analytic data available for access

Timepoint	Specimen Type		Maximum Amount/ Participant	Aliquots	# of Participants
Baseline (2009 – 2017)	Blood	Plasma	1.5-4.5 mL	1-3 cryovials (1.5 mL)	40,056
		Serum	1.5-4.5 mL	1-3 cryovials (1.5 mL)	
			2.4 mL	6 cryovials (0.5 mL)	
		RBCs	1.5 mL	1 cryovial (1.5 mL)	
		Buffy Coat	0.75-1.0 mL	1 cryovial (1.8 mL)	
		Lymphocytes	1.0 mL	1 cryovial (1.0 mL)	5,962
	Urine		3 mL	2 cryovials (1.5 mL)	12,600
	DNA (Buffy Coat)			Up to 1.5ug	24,563
2020 - 2023	Dried Blood Spots		Up to 3	N/A	9,956

Timepoint	Data	# of Participants
Baseline: Immediate Blood analysis	Complete Blood Count (CBC)	31,442
	Glycosylated hemoglobin (HbA1c)	
Ongoing	Genotyping (UKBIObank Affymetrix arrays)	~22,000
	Inflammatory markers (cytokines)	1,440
	scRNA Sequencing	~400
Antibody Study	Anti-N IgG levels (anti-SmT1, anti-RBD, anti-N)	9,956

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Comprehensive physical measures data

Physical measures

Anthropometric measures Height, sitting height, waist and hip circumference, weight

Bioimpedance BMI, impedance, % body fat, fat mass, fat free Mass, total body water, basal metabolic rate

Grip strength Right and/or left hands

Bone density Heel of non-dominant leg: Stiffness index, % young adult, T score, % age matched, Z-score, BUA and SOS values

Lung function Timed peak and forced inspiratory and expiratory flow, vital capacity: FVC, FEV1, FEV1/FVC, FEF25, FEF50, FEF75, FEF25-75, FET, FEV3, FEV3/FVC, FEV6, PEF, EVol, FIVC, FIV1, PIF, ELA. MVV.

Blood pressure Systolic and diastolic blood pressure, heart rate

MRI (n=3,100 participants) Full body, n=3,100 participants, Combination of hospital centres and mobile units.

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Reported medication usage

- **224,771** participants completed the OHS baseline questionnaire (2009-2017).
- **89,637 (39.9%)** listed at least one medication in response to question "*Are you currently taking any medications prescribed by a doctor and dispensed by a pharmacist?*"
- Top **10** frequently-prescribed medications:

Rank	Medication	Indicated Use
1	Synthroid	Hypothyroidism
2	Apo-Atorvastatin	Statin (CVD, blood pressure)
3	Crestor 10 mg	Statin (Rosuvastatin)
4	Eltroxin	Hypothyroidism
5	Coversyl	ACE inhibitor (CVD, blood pressure)
6	Crestor 20 mg	Statin (Rosuvastatin)
7	Apo-hydro	Anti-hypertensive; diuretic
8	Teva-hydrochlorothiazide	Anti-hypertensive; diuretic
9	Celebrex	COX2-Inhibitor NSAID
10	Apo-salvent	Bronchodilator (Asthma)

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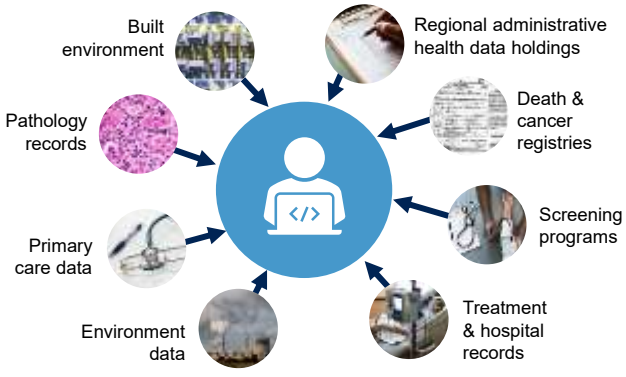
Linkages with administrative health data

- The OHS is a population-based cohort study that provides a platform for data- and biospecimen-based investigations of:
  - Environmental
  - Lifestyle
  - Clinical
  - Molecular
  - Genetic factors

  associated with cancer and other chronic diseases.
- Prospective study design allows biomarkers to be measured in samples collected before the clinical occurrence of disease



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Linkages with OHS Data

188,000+ OHS participants recruited between 2009 and 2017 have been linked to Ontario Health and ICES data holdings

Ontario Health
Cancer Care Ontario

- Within OH holdings, the **Ontario Cancer Registry** captures:
  - Hospital admission and discharge information from CIHI
  - Pathology reports from hospitals and community labs
  - Consultation and treatment records of patients from regional cancer centres or their associated hospitals
  - Death certificates
- Incident cancer cases ascertained via record linkage and staged according to the TNM classification system

IC/ES

- Data sets available through ICES include:
  - Hospital Discharge Abstract Database (DAD)
  - National Ambulatory Care Reporting System (NACRS)
  - Continuing Care Reporting System (CCRS)
  - Ontario Drug Benefit Claims (ODB)
  - Ontario Health Insurance Plan Claims Database (OHIP)
  - Registered Persons Database (RPDB)
  - Ontario Cancer Registry (OCR)
  - Ontario Laboratory Information System (OLIS)

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Linkages to The Canadian Urban Environmental Health Research Consortium (CANUE)

- All OHS participants have been linked to CANUE environmental exposures
- CANUE has built a database of environmental factors (e.g., **local air quality, amount of nearby traffic, access to greenspaces, walkability, social deprivation, climate, and weather**) dating back to the 1980s for each postal code in Canada
- Through Statistics Canada's Social Data Linkage Environment (SDLE) program, OHS participants' previous residences have identified through a residence reconstruction initiative using data from federal documents
- A platform to study climate change impact on the health

CANUE

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OHS Demographics and Health Overview

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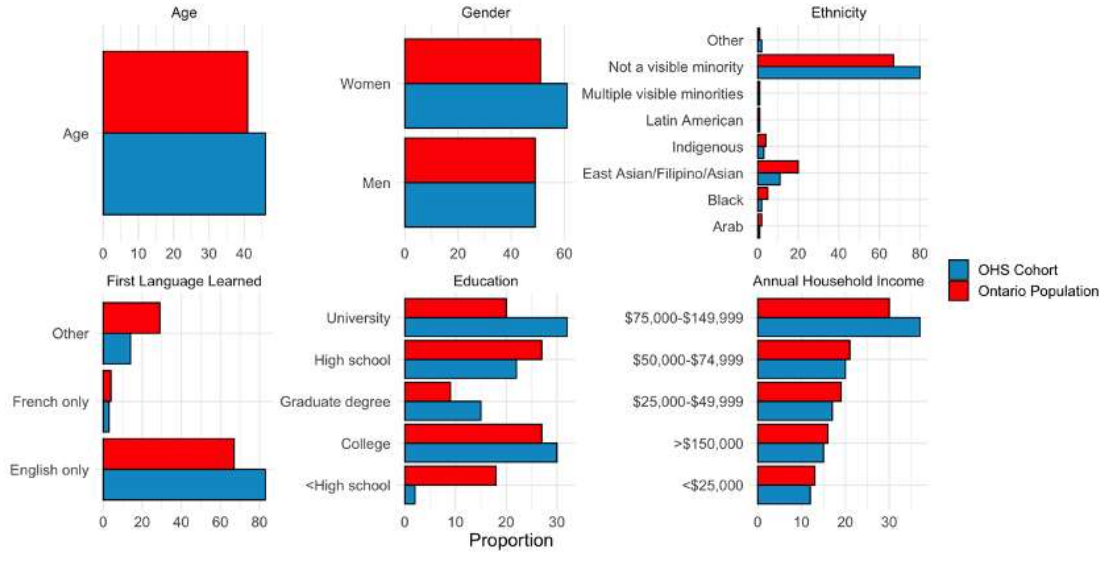
Sociodemographic characteristics of the OHS in comparison to the Ontario Census population (2016)



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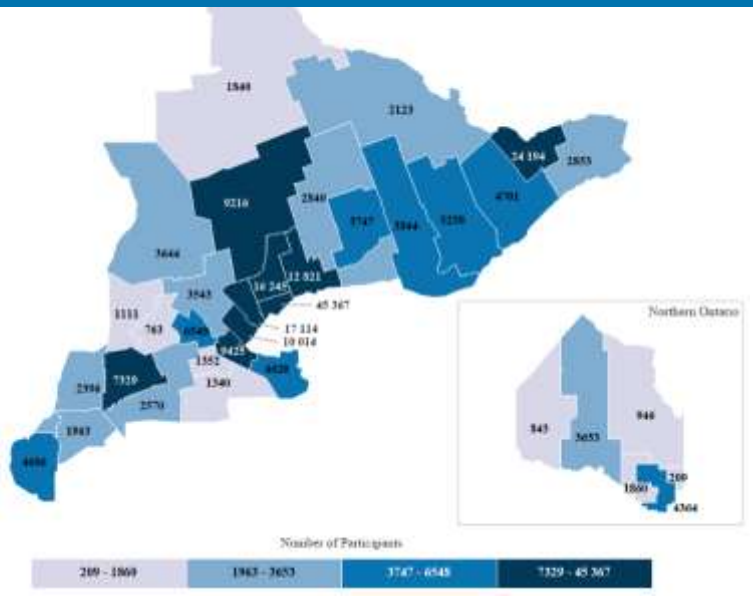
Geographic Distribution of Ontario Health Study



Kirsh et al. 2023, Int. J. Epi.

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Most commonly-diagnosed cancers in cohort

Cancer Type	Total (N=188,351)[a]			Provided blood (N=38,799)		
	Prevalence[b]	Incidence[c,d]		Prevalence[b]	Incidence[c,d]	
	n	n	Per 100,000 person-years	n	n	Per 100,000 person-years
Breast (female)	2535	1870	190.2	926	415	263.3
Prostate	2194	1699	266.3	683	456	441.9
Skin (melanoma)	972	834	50.1	315	204	74.9
Colorectal	960	969	58.2	275	167	61.2
Thyroid and other endocrinal	829	522	31.3	285	93	34.1
Lymph node	653	335	20.1	191	77	28.1
Haemotologic	469	956	57.2	139	217	79.3
Uterine	468	540	53.6	176	134	81.8
Bladder	321	580	34.7	97	126	46
Renal	312	357	21.3	104	73	26.6

a Includes participants who consented to administrative linkages; mean (SD) age in years is 47 (15) overall and 57 (10) among those who provided a blood sample.
b Ascertained through linkage with the Ontario Cancer Registry from 1 January 1964 through to date of enrolment; self-reported cancer history is also available.
c Ascertained through linkage with the Ontario Cancer Registry covering the period from baseline to 31 March 2021.
d Average follow-up time is 8.7 years; 1,634,839 total person-years of observation.

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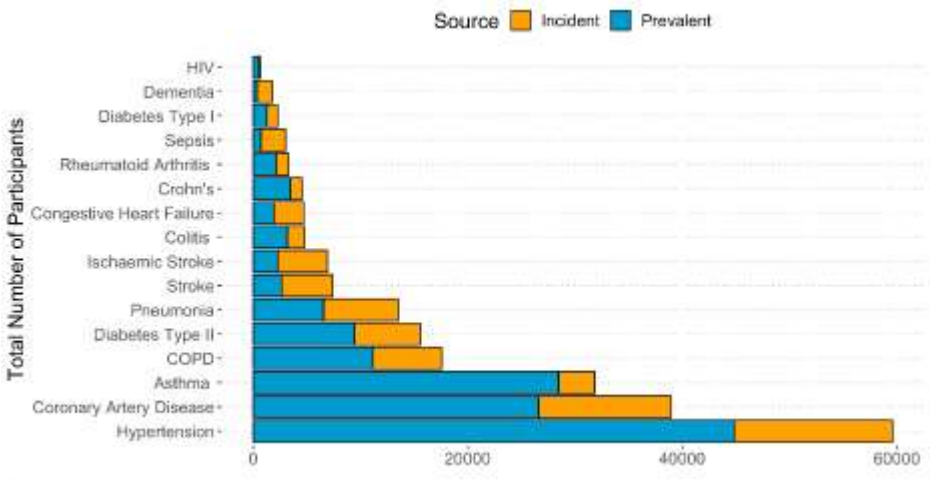
Common diseases and conditions identified through ICES



Total Number of Participants:
225,000

Mean age at recruitment:
46.4 years
(SD = +/-15.0)

*Linkages reflect diagnoses captured up until March 2020 through Institute for Clinical and Evaluative Sciences (ICES)

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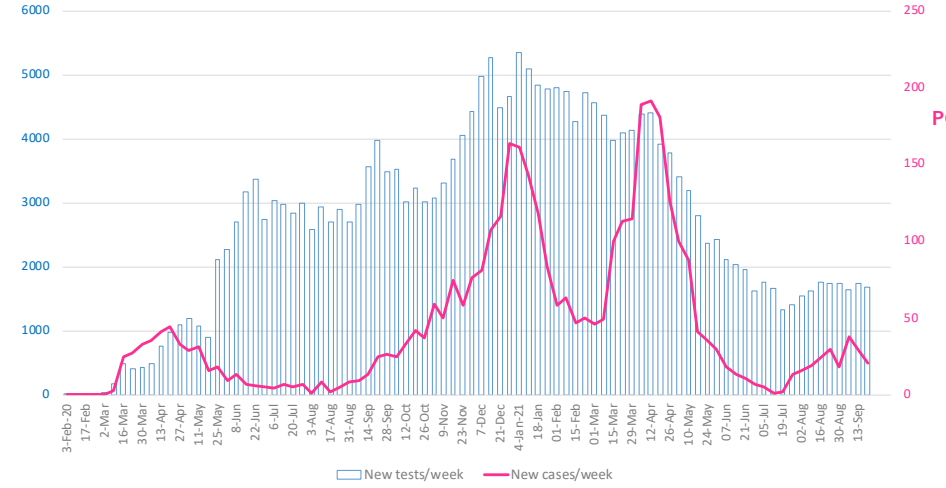
COVID-19 cases identified through linkage to the Ontario Laboratory Information Systems (OLIS)



PCR-confirmed SARS-CoV-2 infections :
3,813

RT-PCR-based COVID-19 tests performed :
229,167

*Linkages reflect diagnoses captured from January 25, 2020 to September 20, 2021 through Institute for Clinical and Evaluative Sciences (ICES)

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Environmental exposures

CANUE

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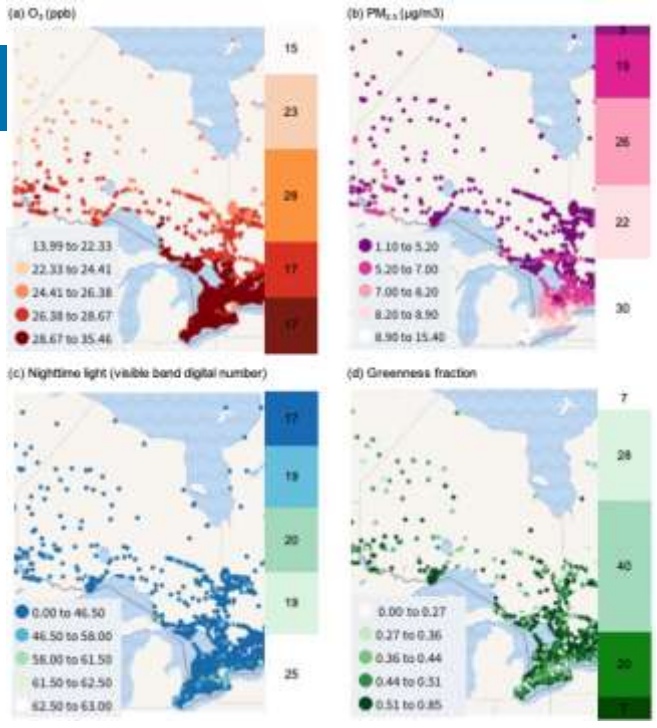
- **Residential exposures to ozone, air pollutants, nighttime light and green spaces are highly variable** across the study population
- **Distribution is skewed toward more urban exposure levels**, as expected, since more than 80% of the Canadian population lives in urban areas



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Ontario Health Study

Scientific Discoveries and Priorities

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Select scientific discoveries supported by the OHS

- Low body mass index, high waist circumference, lower parity, and familial history of breast cancer, were associated with increased risk of **breast cancer diagnosed before age 50**. (Pader J et al., *Cancer Causes Control* 2021)
- Low fruit and vegetable intake and short or long sleep (≤6 or >9 hrs/night, respectively) were associated with increased risk of **lung cancer among non-smokers**. (Murphy RA et al., *in submission* 2021)
- Diabetes was associated with MRI-identified vascular brain injury and cognitive impairment, implicating small vessel disease as an important link between **diabetes and cerebrovascular disease**. (Gerstein HC et al., *J Clin Endocrinol Metab* 2021)
- Atopic dermatitis was not associated with hypertension, type 2 diabetes, myocardial infarction or stroke, suggesting that it is not likely a major risk factor for **cardiovascular disease**. (Drucker AM et al., *Br J Dermatol* 2017)
- Increased total physical activity, vigorous-intensity activity, and walking were associated with decreased prevalence of **obstructive sleep apnea**. (Hall KA et al., *J Clin Sleep Med* 2020)
- Ethnocultural minorities were more likely to report suffering from **mental health** issues but less likely to access treatment. (Grace SL et al., *BMC Psychiatry* 2016)
- People who live in neighborhoods with a higher density of trees on their streets report significantly higher health perception and significantly fewer **cardiometabolic conditions**. (Kardan et al., *Sci Rep* 2015)

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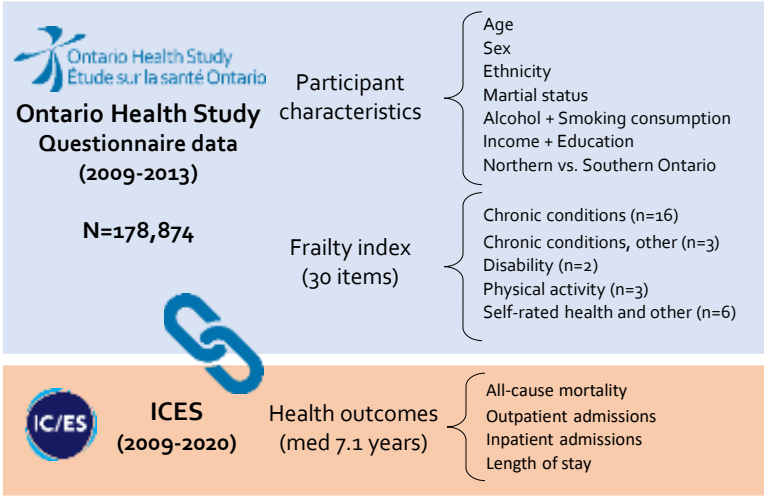
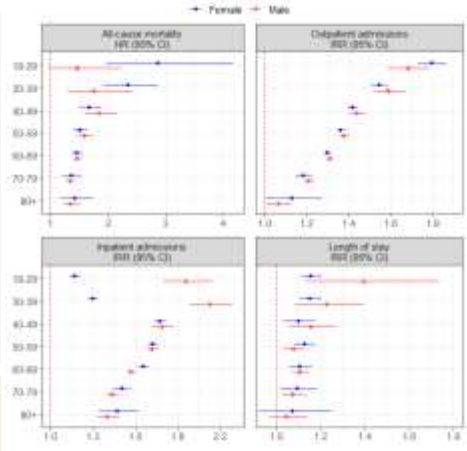
Associations of frailty with mortality and healthcare utilization

Verschoor, C. P., Theou, O., Ma, J., et al. (2024). **Age- and sex-specific associations of frailty with mortality and healthcare utilization in community-dwelling adults from Ontario, Canada.** *BMC Geriatrics, 24*, 223.





Frailty is associated with health outcomes **at all ages**

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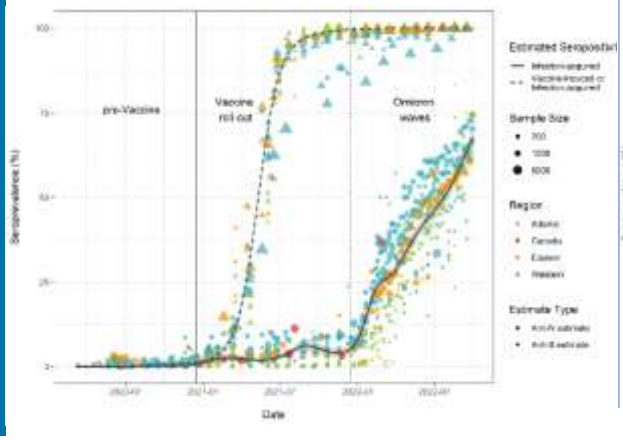
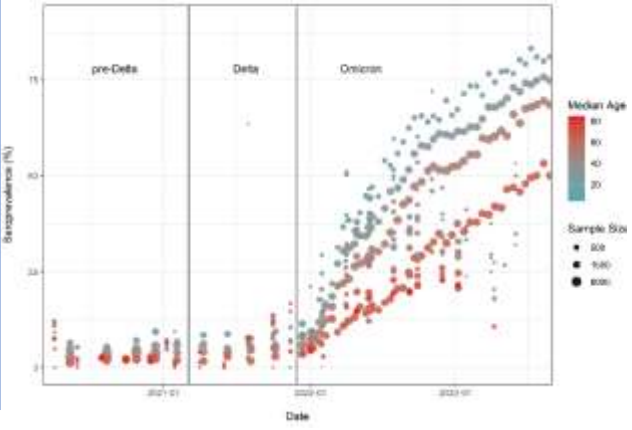
SARS-CoV-2 seroprevalence (Mar 2020 - Sep 2022)

Vaccine-induced and infection-acquired seropositivity for all age groups, by region:



Infection-acquired seropositivity, by age:



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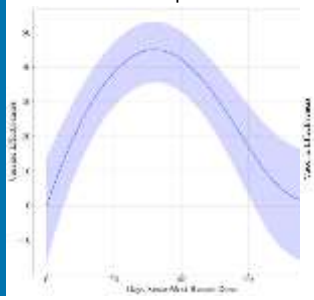
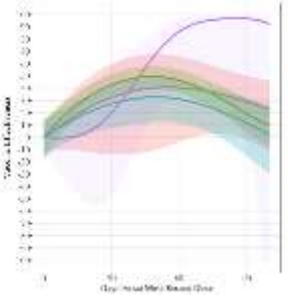
Vaccine effectiveness during the Omicron period

- 45 days after receipt of the dose, VE = 44.9% (95% CI, 35.3 to 53.0)
- 90 days after receipt of the dose, VE=16.9% (95% CI, 2.7 to 28.9)
- Patterns similar in the dose-specific model and across age groups
- VE comparable between vaccine products (up to four months after vaccination):
  - 49.5% for the monovalent Moderna vaccine
  - 45.8% for the monovalent Pfizer-BioNTech vaccine
  - similar in monovalent and bivalent booster recipients

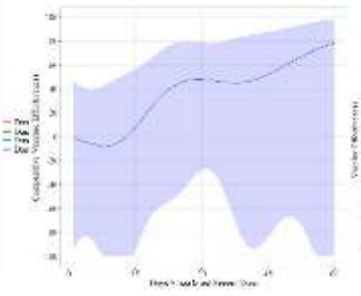
Omicron period



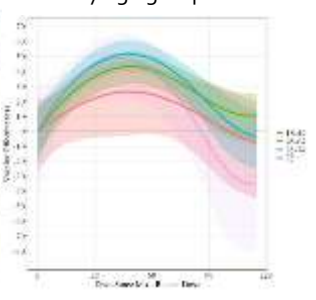
By dose number



Bivalent vs. monovalent



By age group



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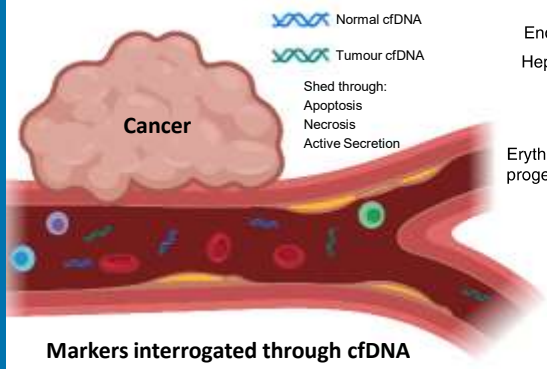
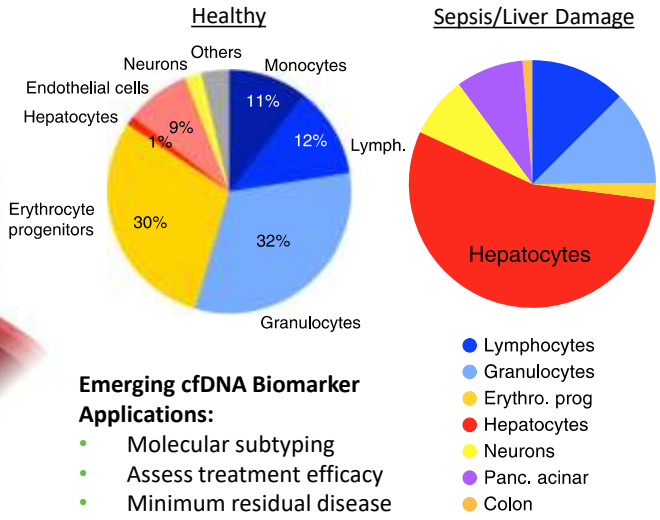
cfDNA shedding patterns can inform overall health and underlying diseases





Markers interrogated through cfDNA

- Somatic Mutations
- Methylation patterns
- Chromatin occupancy
  (fragment positioning patterns)
- Fragment lengths

Moss, Magenheim, Neiman et al. 2018 *Nature Communications*

Emerging cfDNA Biomarker Applications:

- Molecular subtyping
- Assess treatment efficacy
- Minimum residual disease
- Detection of recurrence
- Early cancer detection

Nicholas Cheng
Plenary presentation at ASHG 2021, Manuscript in prep

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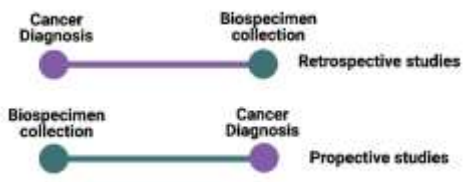
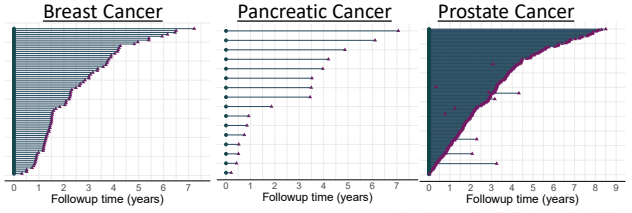
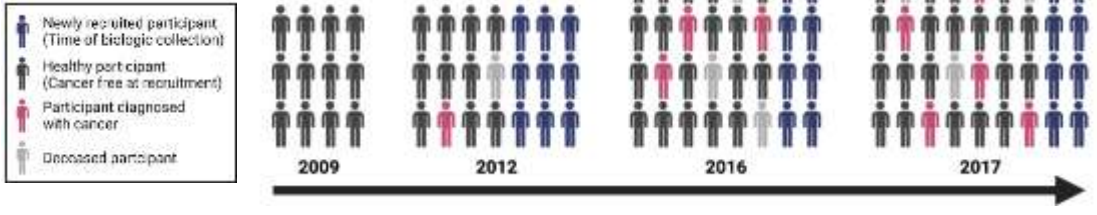
Leveraging prospective cohorts to identify cancer markers prior to clinical detection





Ontario Health Study

- Over 225,000 participants in Ontario recruited between 2009-2017
- Blood plasma collected from over 55,000 participants at time of study recruitment
- Linkage of participants to administrative health records identified participants that developed cancer following study recruitment



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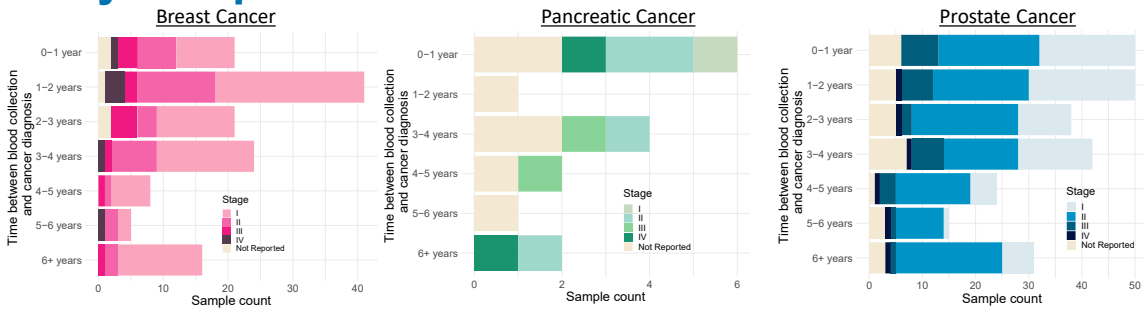
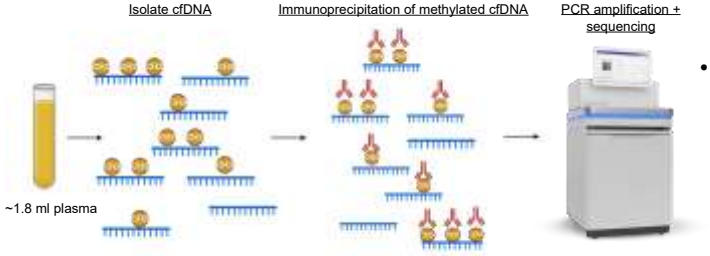
Profiling pre-diagnosis blood samples collected up to 7 years prior to cancer detection



Cancer-free controls matched to cases by:

- Age
- Sex
- Sample collection date
- BMI
- Alcohol consumption and smoking frequency



- Processed at OICR by Genome Research Platform team

Shen, Singhania, Fehringer et al. 2019 *Nature*

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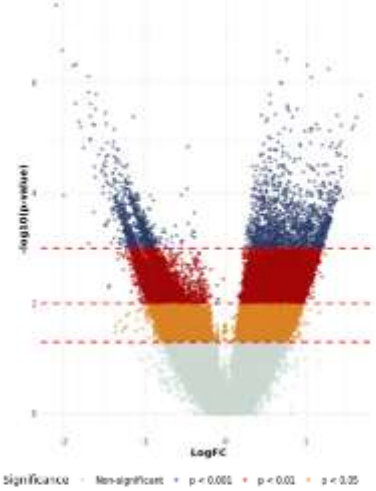
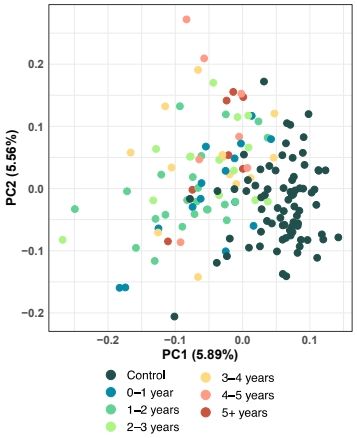
Early breast cancer cfDNA methylome signatures detectable over 5 years prior to diagnosis

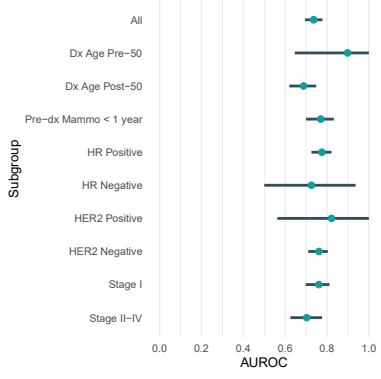
Differential methylation calling between cases and controls (GLM negative binomial model: ~ Age + Batch + Group)



207 cfDNA differentially methylated regions discriminate pre-diagnosis breast cancer cases from controls



Stratified pre-diagnosis breast cancer classification performance



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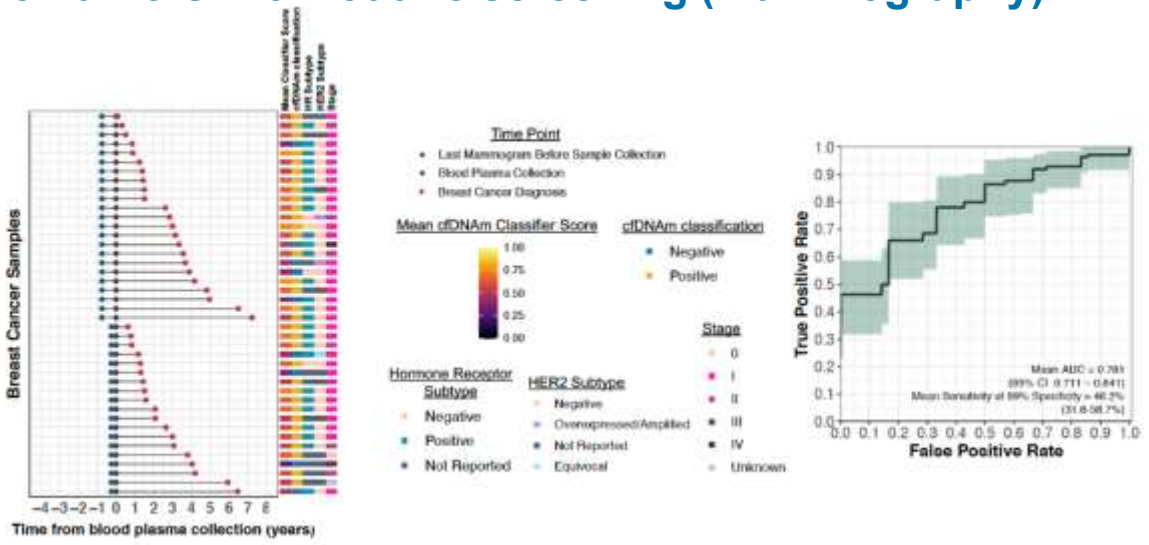
Comparison of predictive performance of early detection biomarkers with routine screening (mammography)



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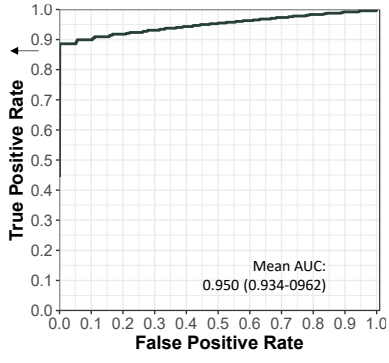
cfDNA methylation signatures are predictive of prostate and pancreatic cancer development

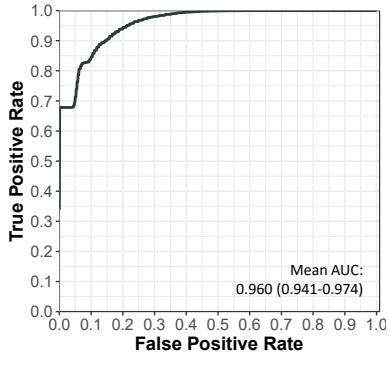
Average random forest classifier performance across 200 prostate subsampled repeats (100 hypermethylated regions)



Train set:
50% Controls (n = 33)
50% Pre-dx PRAD cases (n = 38)
50% Post-dx localized PRAD cases (n = 15)

Test set:
50% Controls (n = 32)
50% Pre-dx PRAD cases (n = 39)
50% Post-dx localized PRAD cases (n = 15)
All Post-dx metastatic PRAD cases (n = 183)

Classifying post-diagnosis pancreatic samples trained with pre-diagnosis cfDNA methylation signatures (Performance across 100 subsampling repeats)



Train set:
50% Controls (n = 57)
All Pre-dx PAAD cases (n = 16)

Test set:
50% Controls (n = 57)
All Post-dx metastatic PRAD cases (n = 24)

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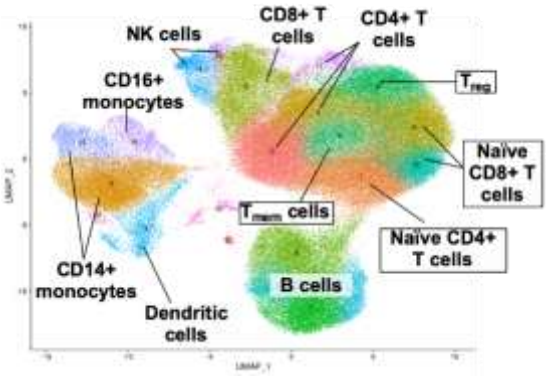
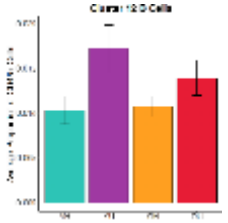
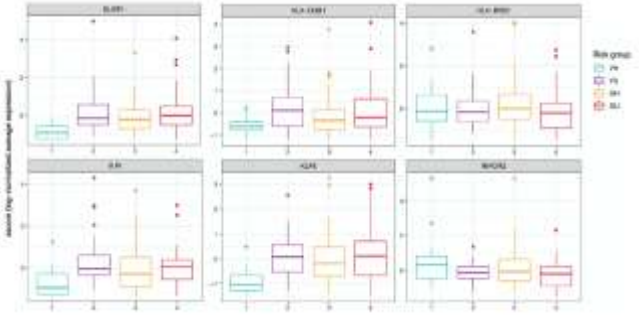
OHS samples support single cell sequencing studies elucidating the genomic landscape of aging





Differential gene expression analysis identifies genes which play a role in healthy aging



Elyssa Bader, oral presentation at ASHG 2020, Manuscript in Prep

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What's next?

- Research community engagement
- More blood collection
- Sequence remainder of participants
- Ancillary Studies (chronic fatigue study, Canadian Alliance for Healthy Hearts and Minds)
- Second Health Status Follow-Up Questionnaire
- Diet and Physical Activity Questionnaire

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Linkage with CIHI data

Linkages between the CanPath cohort and the Canadian Institute for Health Information (CIHI) administrative health data are underway.

Individual-level linked CIHI data (N=290,000) will be hosted alongside the harmonized national CanPath dataset and made available to approved researchers requesting administrative health data along with cohort data and/or samples.

CanPath will be the first Canadian program to be able to combine the wealth of cohort resources with national administrative level data in a central location.

Canadian Institute for Health Information
Institut canadien d'information sur la santé

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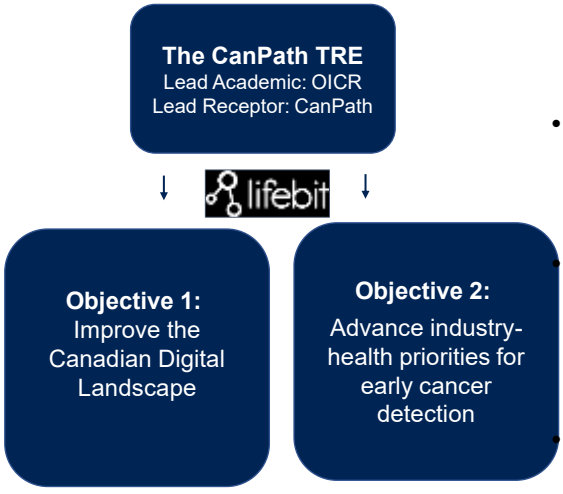
Development of a Trusted Research Environment (TRE)



- The Trusted Research Environment (TRE) will be a **data platform for Canadian researchers to access, analyze, and contribute to research in a collaborative environment**.
- The platform will **set an industry precedent** for collaborative data access and innovation, advancing Canada's global impact in population health research.
- Through development of the platform, **CanPath will be established as the Canadian leader in data governance for genetic and health information research**
- Adopting a TRE model will pave the way for **industry-utilisation of the CanPath resource**

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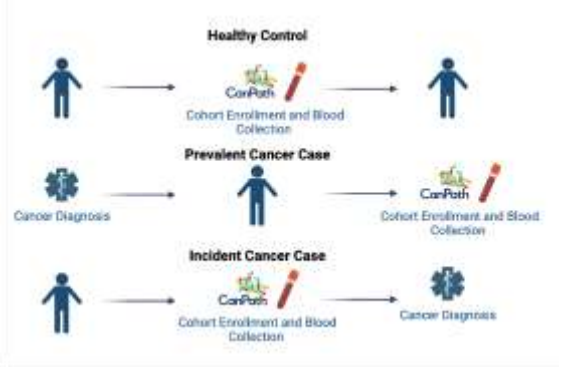
Building the Canadian Cancer Study

- CanPath is building the Canadian Cancer Study to advance research and discovery
- With linked clinical information, we can identify which participants joined the cohort **before developing disease**
- Using samples collected before disease onset, we are able to develop **novel approaches to detect disease years before current methods**
- We are adopting a three-pronged approach to **build the data resources required to enable early cancer prevention and detection research:**
  - Linking to national administrative data holdings
  - Harmonizing aggregate cancer data reporting nationally
  - Hosting linked individual-level cancer outcomes



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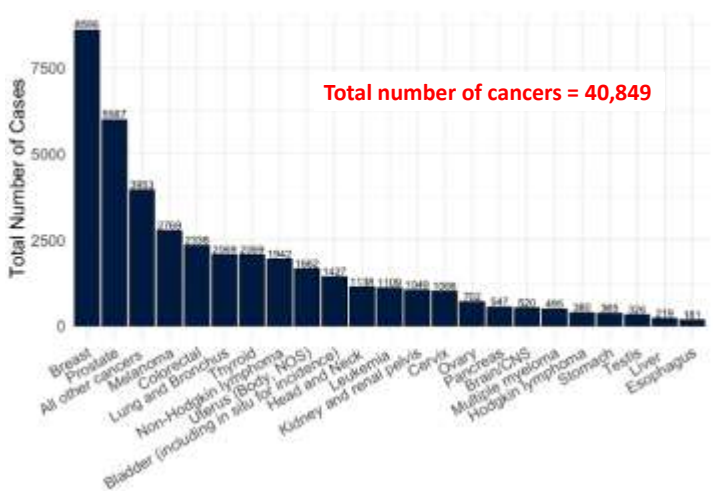
Building the Canadian Cancer Study



CanPath is leveraging provincial linkages to map cancer data and biosample holdings

All cancer data is collected and grouped according to Canadian Cancer Statistic guidelines

Regions included:
- Atlantic PATH
- Alberta for Tomorrow Project
- Ontario Health Study
- BC Generations Project

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Data Access and Utilisation

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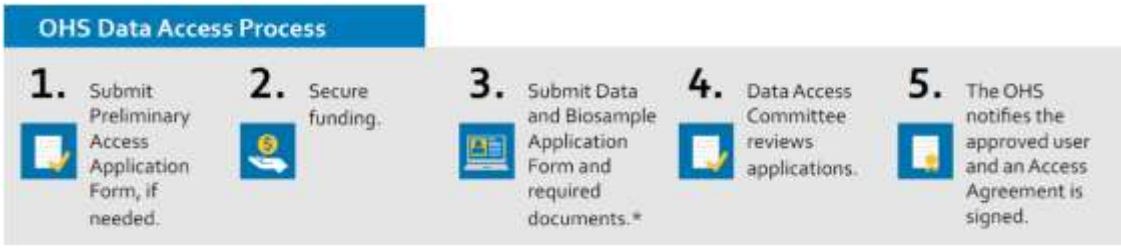
How to access OHS data and biospecimens



*Approval letter from Research Ethics Board (REB) *and* REB-approved research protocol; Evidence of scientific peer-review of research protocol, if available; 2-page CV of Principal Applicant; List of required data linkage to data repositories, if any.

Researchers can now apply for access to de-identified OHS data & biospecimens. Please contact **access@ontariohealthstudy.ca** for more information.

https://www.ontariohealthstudy.ca/for-researchers/data-access-process/

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Ancillary studies: CAHHM



The Alliance is led by **Dr. Sonia Anand**


STUDY PROTOCOL Open Access

Rationale, design, and methods for Canadian alliance for healthy hearts and minds cohort study (CAHHM) – a Pan Canadian cohort study

- Collected detailed information on vascular disease, cardiac disease and cognitive function using MRI scans
- Data collected from ~7,854 Canadians through existing cohorts, including **1,500 First Nations people** living in Canada
- These unique data are being used to evaluate the impact of different **environmental determinants on cardiovascular health**
- **With over 9 peer-reviewed publications, to date**

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Ancillary studies: The Ontario Sleep Study

Dr. Andrew Lim

- Sleep disruption, sleep deprivation and sleep disorders are common, yet we are only beginning to understand their impact on our health and well-being.
- The Ontario Sleep Health Study will study the sleep and biological rhythms of 4,000 Ontarians.
- The goal is to understand better the impact of sleep disruption on health problems faced by Ontarians, including diabetes, heart disease, stroke and Alzheimer's disease, and the impact of our genes on our sleep and circadian rhythms.

The OHS Team

Not pictured:

Rachel Chepesiuk, Research Operations and Access Officer; and

Nazanin Khobzi, Community Liaison

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The OHS is made possible through:

Funders

OICR Ontario Institute for Cancer Research

CANADIAN PARTNERSHIP AGAINST CANCER / PARTENARIAT CANADIEN CONTRE LE CANCER

Participants

The OHS thanks all its participants for generously donating their time, energy and data to make this research possible.

Learn more about the Study

Read the OHS cohort profile paper in the International Journal of Epidemiology (Volume 52, Issue 2, April 2023)

Visit the OHS website at www.OntarioHealthStudy.ca

Contact the OHS Access Officer at access@ontariohealthstudy.ca

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Questions

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