AI and Digital Technology: What does this mean for the future of public health?

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Dalla Lana School of Public Health, University of Toronto
Education Lead, Temerty Centre for Artificial Intelligence Research and Education in Medicine (T-CAIREM)
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AI4PH AI FOR PUBLIC HEALTH

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Presenter Disclosures

AI and Digital Technology: What does this mean for the future of public health?

The following personal financial relationships with commercial interests relevant to this presentation existed during the past 24 months:

No relationships to disclose

2

Framing AI for Public Health

Outline

Context
- How is the digital and computational world changing and why is this relevant for Public Health?

Opportunities
- What are the key features of AI and how do these relate to opportunities for public health?

Mitigating Risks
- How do we mitigate potential risks of AI and digital technology for public health?

Training & Capacity
- How does public health training need to adapt?

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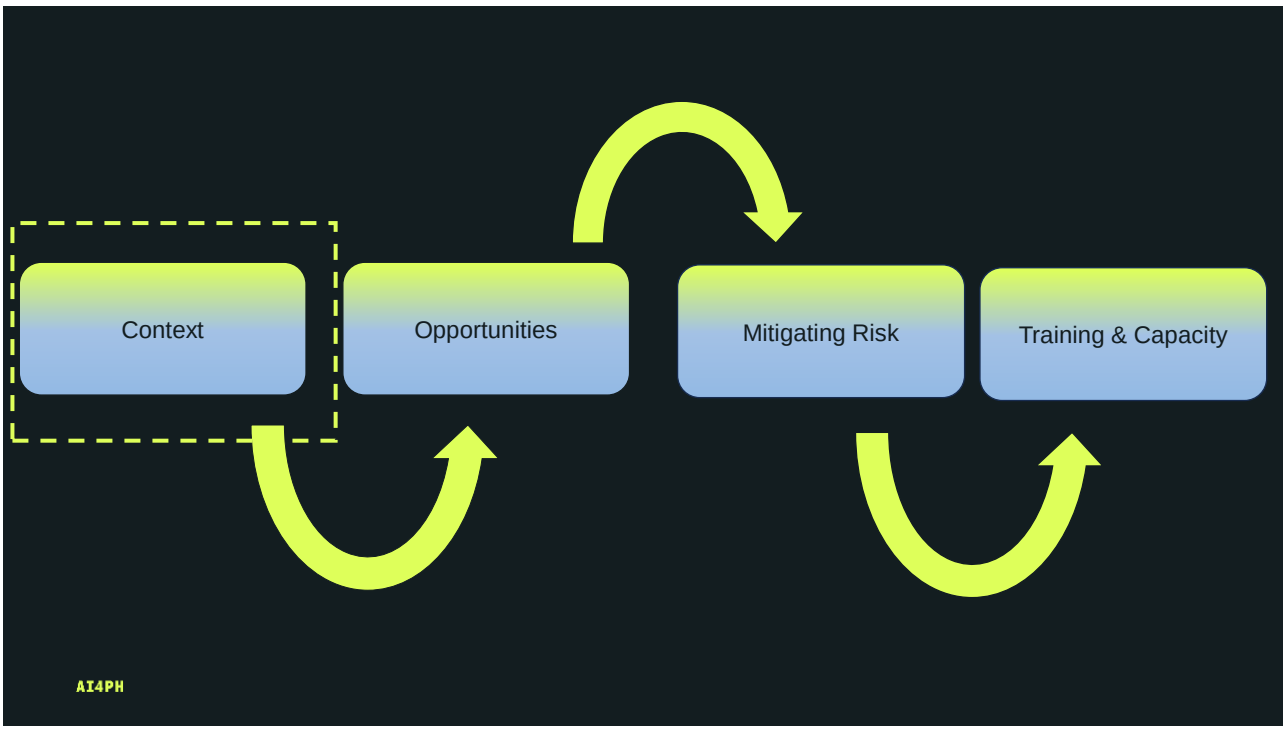

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How will we know if advances in AI are having a positive impact for public health?

⇒Fewer people developing diseases or poor health outcomes that are preventable

⇒Promoting health in our environments and communities

⇒Reduction in health inequities

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Lost in Translation?

Computer Science Term	Epidemiology Term
Features	Independent variables
Labels	Outcomes
Noisy labels	Measurement error
Learning	Fitting
Data mining	Exploratory analyses
Classification algorithm	Algorithm with a categorical outcome
Regression algorithm	Algorithm with a continuous outcome
Precision	Positive predictive values
Recall	Sensitivity
Dimensionality	Number of covariates
Imbalanced data	Unequal outcome distribution
One-hot encoding	Creation of dummy variables

Qifang et al. What is machine learning? A primer for the epidemiologist. AJE, 2019

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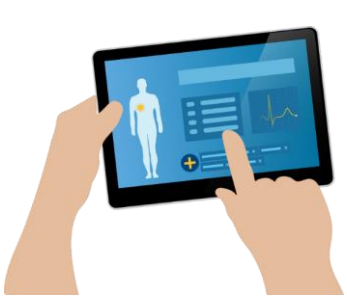
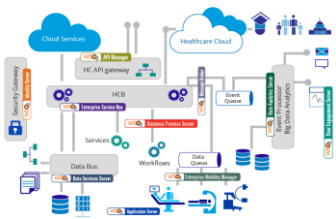
Changing data environment





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Emerging data for public health

Electronic health records

Environmental data

Wearables

Internet sources

9

9

Greater demand for data to support public health decision-making

⇒Public health has a long history of using data to:
- ⇒Understand disease burden
- ⇒Measure disparities
- ⇒Generate causal evidence for interventions

⇒Demand and Scope is increasing:
- ⇒Speed; Transparency: Comprehensiveness

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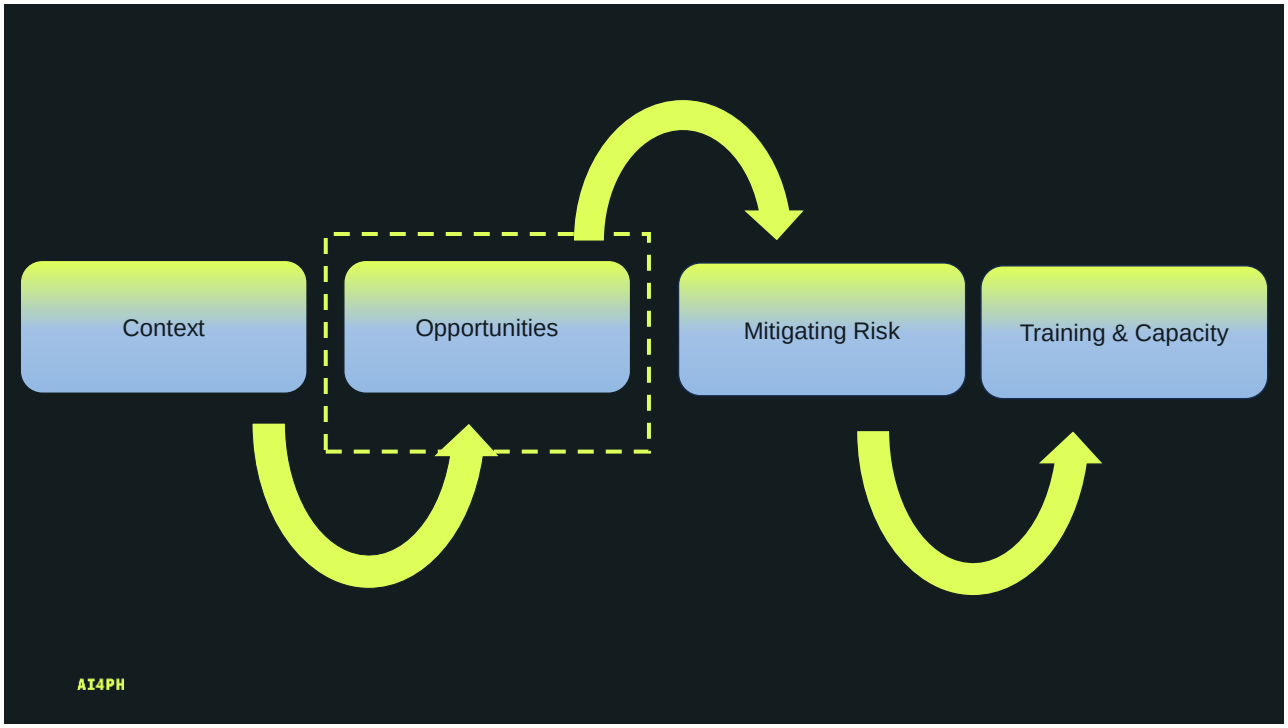
Context
Opportunities
Mitigating Risk
Training & Capacity
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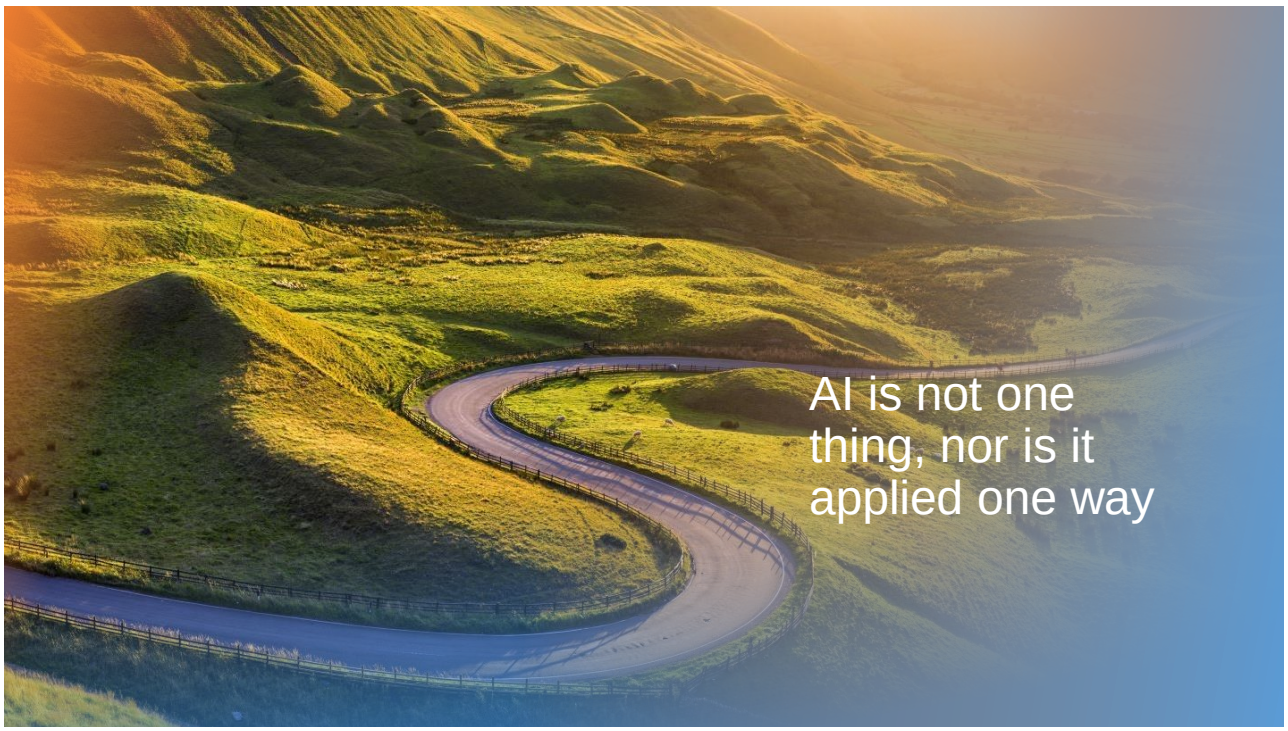
AI is not one thing, nor is it applied one way

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Getting more specific on AI applications

Descriptive

Predictive

Causal Inference

Prescriptive

Hernan et al. CHANCE 2019

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Getting more specific on AI applications

What is happening?

What will happen?

Why does it happen?

What should I do about it?

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Getting more specific on AI applications

What is happening? → Surveillance, Early Detection

What will happen? → Planning, Resource delivery, Prioritization

Why does it happen? → Interventions, Policies/legislation

What should I do about it? → Recommendations, Automated systems

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How is AI being applied in public health?

- Exposure Assessment using Environmental Images
- Administrative Tasks
- Surveillance using Text-based Sources
- Chatbots
- Population Risk Stratification
- Exposure Assessment from Wearables

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PoRTs by the Population Health Analytics Lab

Diabetes	DPoRT	CDPoRT	Multiple Chronic Diseases
High Health Care Use	HRUPoRT	PremPoRT	Premature Mortality
Avoidable Hospitalizations	AvHPoRT	PregPoRT	Pregnancy Outcomes

Population Health Analytics Laboratory

http://pophealthanalytics.com/

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Opportunity: Large, linked and routinely collected health administrative databases that contain person-level data on billing codes, procedures, medications, geography and demographic information + survey data

- Generally, focused on a supervised classification task (e.g., a probability of disease, state or healthcare event) and optimizing predictive performance
- Flexibility; Can require fewer assumptions in underlying data structure, which *can* result in improved performance
- Some applications of unsupervised tasks related to identifying subgroups i.e., unpacking patient heterogeneity or segmentation

Rosella LC, Harish V. Machine Learning Applied to Routinely Collected Health Administrative Data. Healthc Q. 2022 Apr;25(1):12-16.

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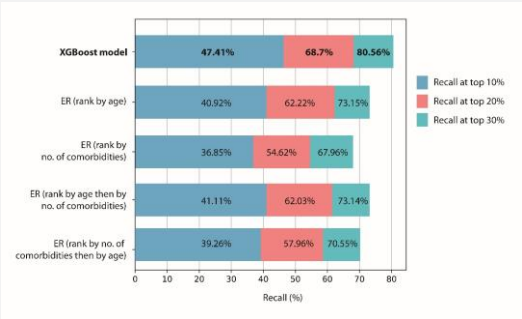
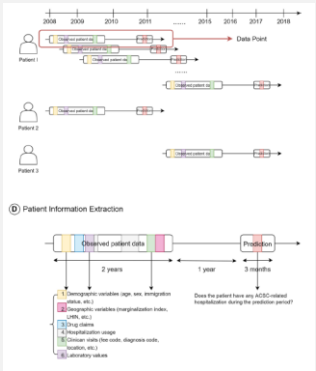
Population-level and health system applications

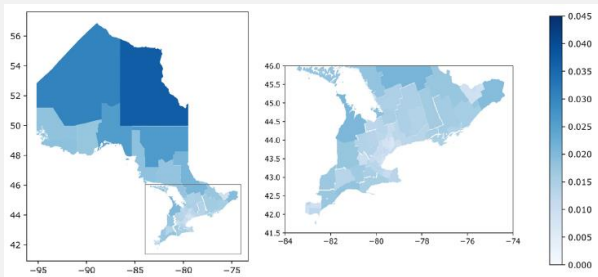
Comparison of model-based recall versus empirical rules to inform COVID-19 vaccine prioritization (Gutierrez et al., 2021)



Ravaut *et al.* NPJ Digital Medicine 2021
Ravaut *et al.* JAMA Network Open 2021



Predicting Ambulatory Care Sensitive Conditions across Ontario
(Yi et al., 2021)



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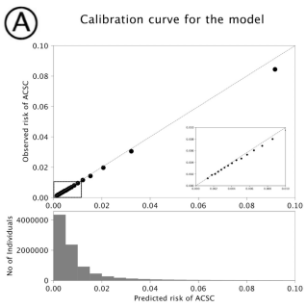
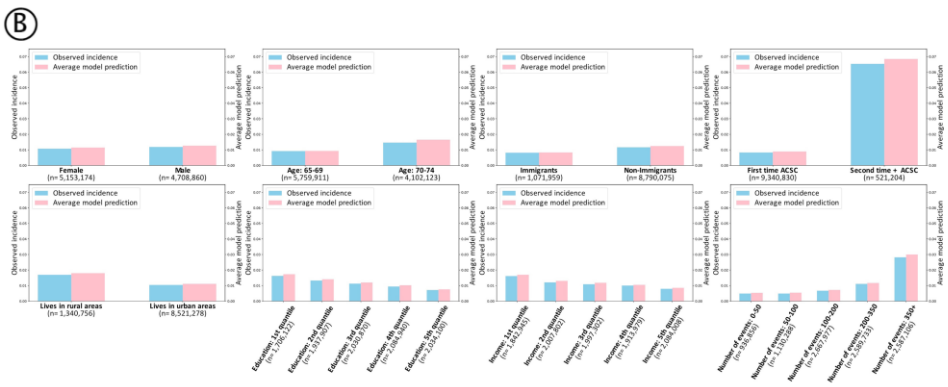


Fairness and the importance of sub-group assessment



(Yi et al., 2021)

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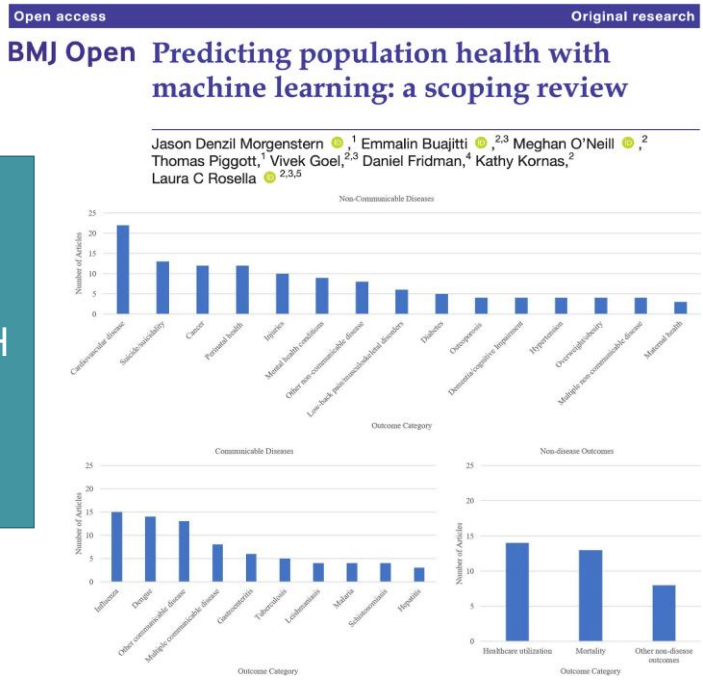
- Mostly structured data
- Opportunities to better address and integrate SDOH
- Greater attention is needed to calibration



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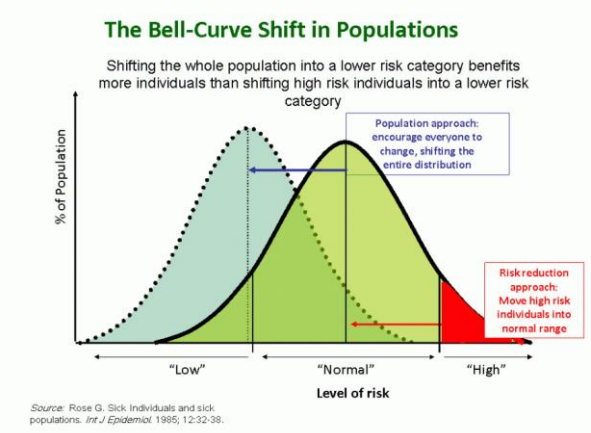
"PRECISION" PUBLIC HEALTH

"Improving the ability to prevent disease, promote health and reduce health disparities in populations by applying emerging methods and technologies for **measuring** disease, pathogens, exposures, behaviours and susceptibility in target populations; and developing policies and **targeted** implementation programs to improve health"

- *Targeting* of the right intervention to the right population at the right time



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Khoury MJ, Galea S. Will precision medicine improved population health? JAMA 2016; 316(13):1357-8.

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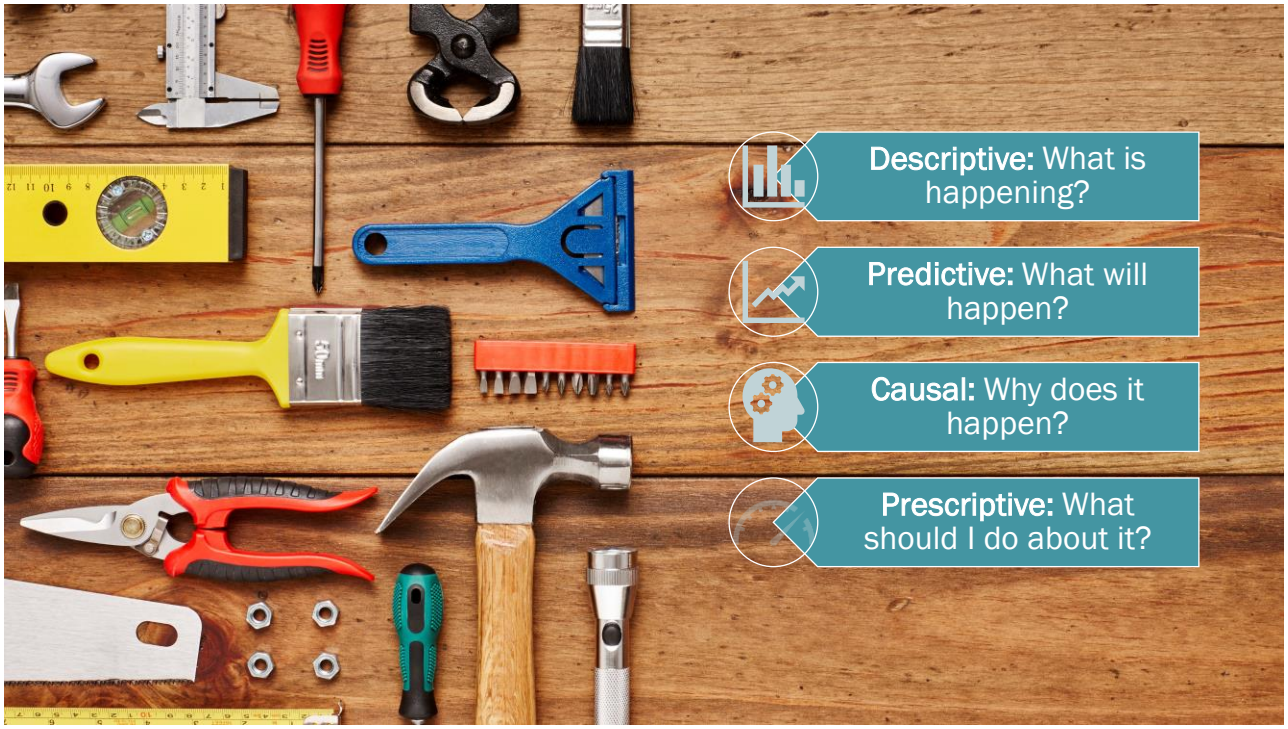
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Prescriptive: What should I do about it?

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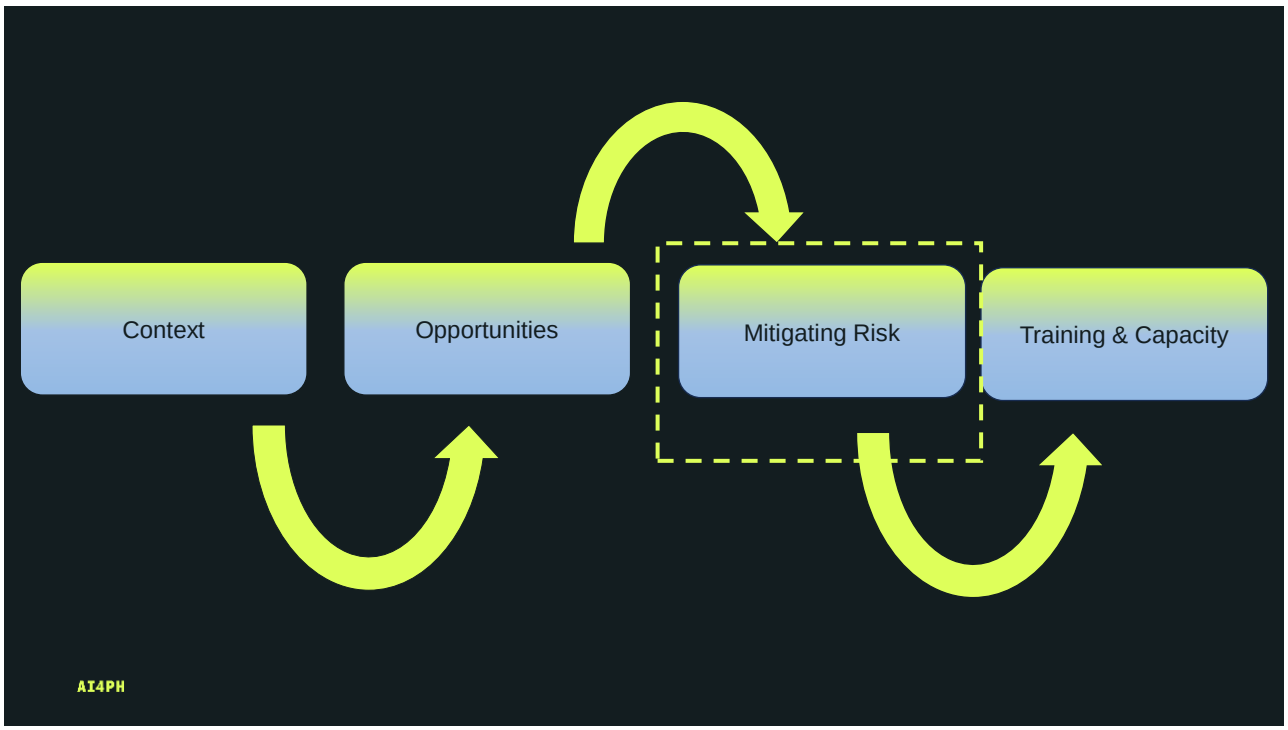
Context
Opportunities
Mitigating Risk
Training & Capacity
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RESEARCH ARTICLE Open Access

"AI's gonna have an impact on everything in society, so it has to have an impact on public health": a fundamental qualitative descriptive study of the implications of artificial intelligence for public health

Jason D. Morgenstern[1], Laura C. Rosella[2,3,4,5], Mark J. Daley[5,6,7,8,9], Vivek Goel[2,3], Holger J. Schünemann[1,10] and Thomas Piggott[1*]

Morgenstern JD et al. "AI's going to have an impact on everything in society, so it has to have an impact on public health": a fundamental qualitative descriptive study of the implications of artificial intelligence for public health. BMC Public Health 2021; 21:40.

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Morgenstern, J.D., Rosella, L.C., Daley, M.J. *et al. BMC Public Health* **21,** 40 (2021).

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- Algorithmic Bias
- Data Quality
- Real-world Implementation
- Black Box
- Oversight and Regulation

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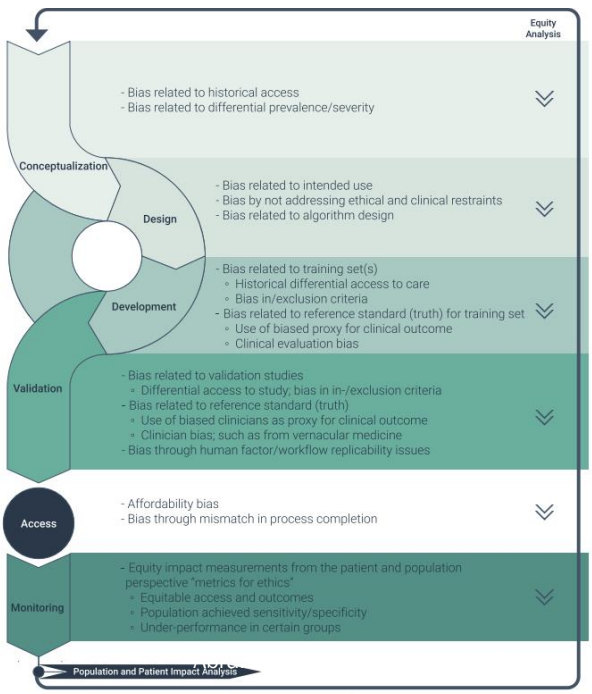
Algorithmic bias

- Biases in data reflect biases in society and will lead to biased algorithms
- Impact of these biases can be exacerbated in the decisions made using biased algorithms
- Requires an understanding and measurement of the biases in the data sources and models



Abramoff et al. NPJ (2023)6:170

Fig. 1 Total Product LifeCycle (TPLC) equity expanded framework with examples for each phase.

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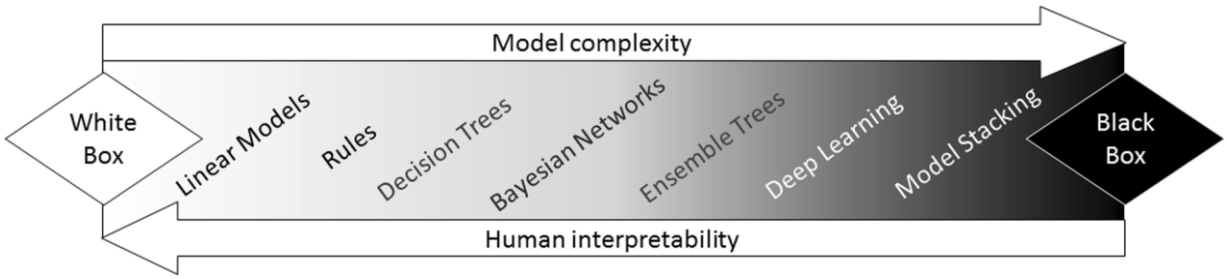
- **Interpretability:** How the model parameters are influencing the model
- **Explainability:** How the algorithm influences decisions made based on that model
- **Transparency:** How the model was created and validated



From Prosperi et al BMC Medical Informatics and Decision Making (2018): Big data hurdles in precision medicine and precision public health

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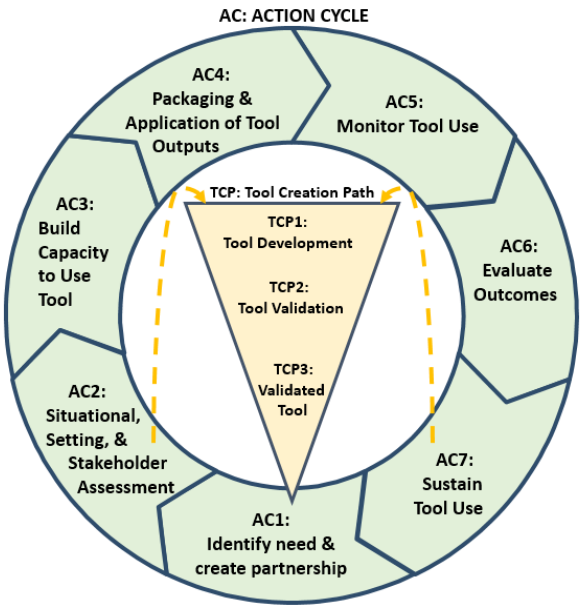
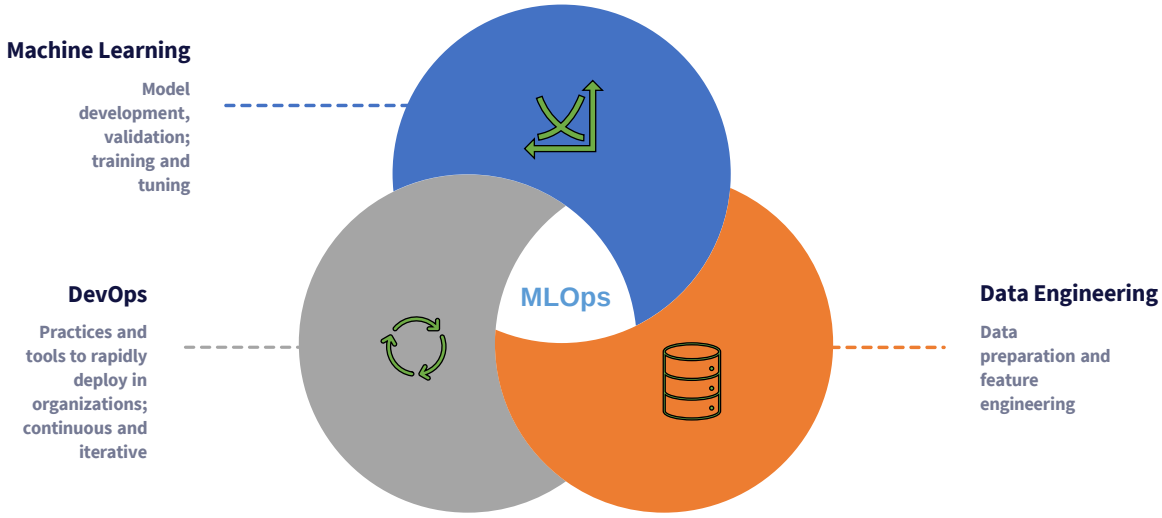


- How does it perform?
- What impact (positive or negative) is it having?
- What needs to be done to build capacity and sustain use?

Population Health Analytics Laboratory

Peirson & Rosella. *J Contin Educ Health Prof,* 35(2): 139-147

Hybrid Teams in a MLOps Framework



Alla S., Adari S.K. (2021) What Is MLOps?. In: Beginning MLOps with MLFlow. Apress, Berkeley, CA.

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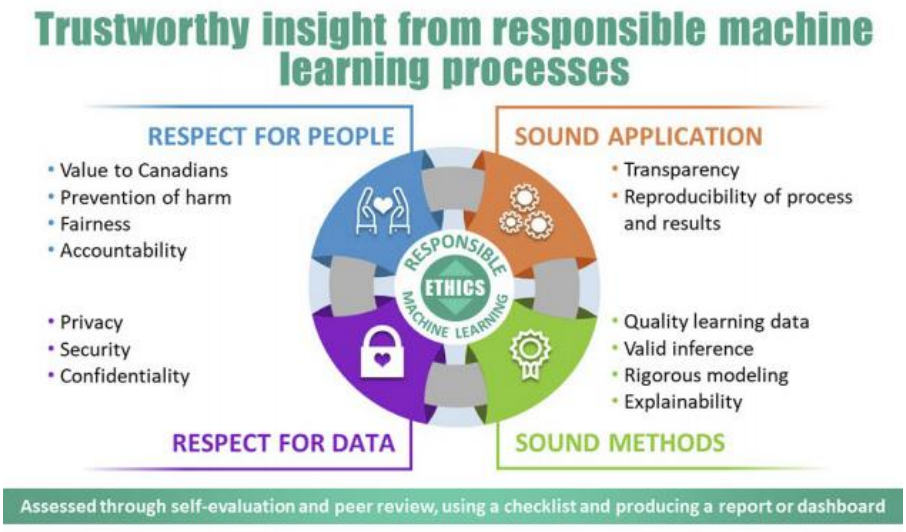

JULY 2020 STATISTICS CANADA

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Artificial Intelligence and Data Act (AIDA)

- Tabled in June 2022 as part of Bill C-27

Covers:

- Safety and human rights
- Supports new regulatory development
- Prohibit reckless and malicious uses of AI

- Proposes enforcement mechanisms

Government of Canada / Gouvernement du Canada

The Artificial Intelligence and Data Act (AIDA) – Companion document (canada.ca)

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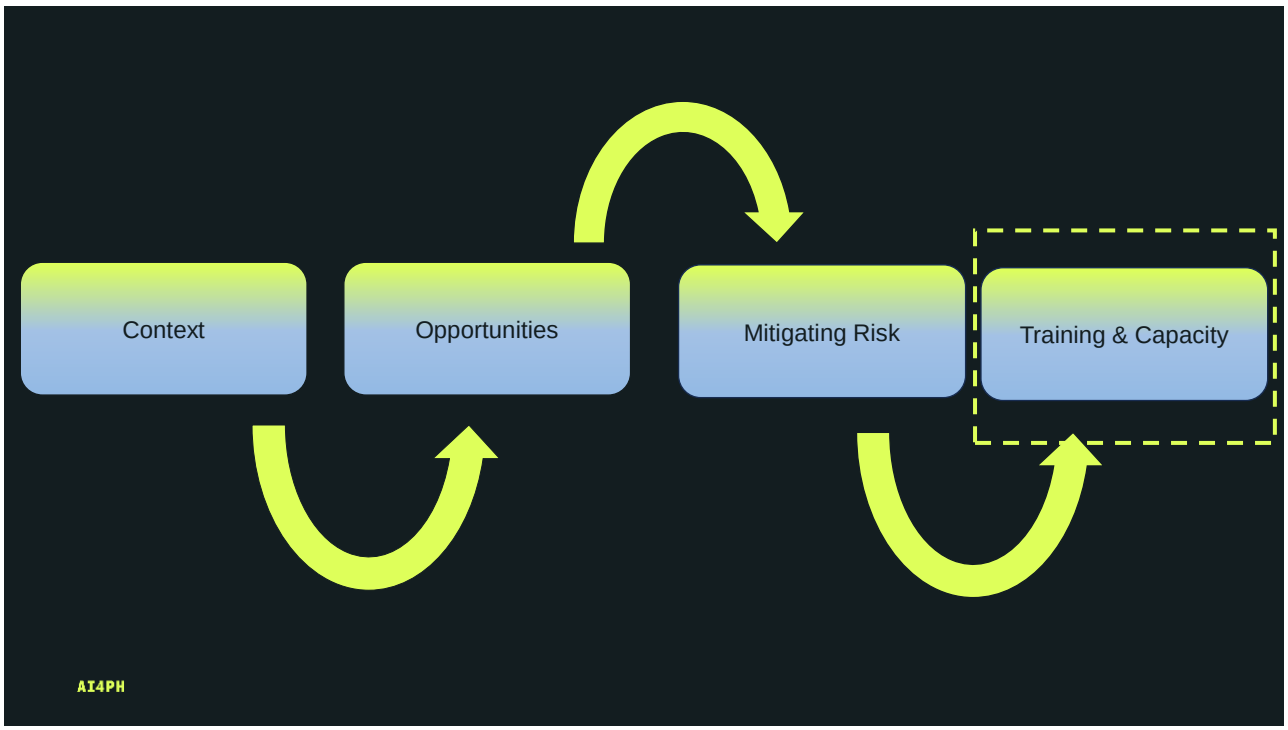

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Training and Capacity Building

Data Science & Public Health: What is Needed?

New courses needed across data science spectrum	Advanced data analysis, machine learning/artificial intelligence, data communication, data management, novel data handling, and data use/ethics
Integrating socio-behavioral science principles into data science	Increased focus on the social and political dimensions of data and its use
Lifelong learning opportunities	Technology & methods are rapidly evolving; plans for rapid upskilling are needed
Informal learning opportunities and mentorship	Advance interdisciplinary connections and diversity in the public health field

*Mirin, N., Mattie, H., Jackson, L., Samad, Z., & Chunara, R. (2022). Data Science in Public Health: Building Next Generation Capacity. Harvard Data Science Review, 4(4).

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Health Research Training Platform (HRTP)

AI, Public Health and Equity

HRTP focused on building capacity in AI and big data skills for transformative change in addressing population and public health challenges and understanding how these tools impact health equity.

Expected to achieve the following outcomes:

- Build AI and big data skills with the intent to support career trajectories across different sectors and disciplines;
- Train participants on how and when to leverage and apply AI tools to tackle persistent and complex public health challenges; and
- Train participants on how to identify sources of inequity in data and data tools, and how to use AI to promote equity in health-related decision-making, programming, practice and policy.

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AI for Public Health (AI4PH)

Mission & Approach

MISSION

To establish a workforce of public health researchers and practitioners who develop and apply innovations in equitable artificial intelligence (AI) and machine learning (ML) to public health research, policy, and practice in Canada.

APPROACH

Develop a suite of training activities and opportunities dedicated to facilitating the application of equitable AI applied to public health research, policy, and practice.

Our platform will focus on skill development and capacity-building to apply AI and ML innovations to Canada's most pressing public health challenges that address the social, cultural, and environmental determinants of health.

AI4PH APHA 2023

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

AI4PH is supported by the Canadian Institutes of Health Research (CIHR)

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Dr. Laura Rosella


Dr.Lisa Lix


Dr.Lisa Fan


Dr. Maureen Anderson


Dr. Nathaniel Osgood

AI4PH AI FOR PUBLIC HEALTH

McGill University · University of Regina · University of Saskatchewan · University of Toronto · University of Manitoba · University of Calgary


Dr. David Buckeridge


Dr.Joon Lee

https://ai4ph-hrtp.ca/

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AI4PH Program Elements

⇒Scholarships

⇒Internships

⇒Short Courses and Certificate Program

⇒Workshops

⇒Summer Institute

⇒Annual Networking Meeting

AI4PH APHA 2023

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AI4PH AI FOR PUBLIC HEALTH | Selected Scholars

Jo-Ann Osei-Twum, UofT

PROJECT TITLE: Critical Analysis of a Population Segmentation Method and the Associated Health Equity Implications

Esther Davies, UofT

PROJECT TITLE: A public health solution to inequitable (in)fertility care: Exploring the opportunities and ethical considerations of using AI technology (in)fertility care

Behrad Taghibeyglou, UofT

PROJECT TITLE How to promote equitable sleep care among people experiencing homelessness: An AI-enabled person-centred computer vision-based solution

Ingrid Giesinger, UofT

PROJECT TITLE: Addressing the single-risk factor framework through machine learning: applications in multimorbidity

Zoha Khawaja, SFU

PROJECT TITLE: Guiding Ethical Design and Usage of Voice-Based Virtual Conversational Agents in Digital Mental Healthcare: Fostering Responsible AI Therapeutic Support

Anasua Kundu, UofT

PROJECT TITLE: Determinants of vaping cessation among youth e-cigarette users

AI4PH https://ai4ph-hrtp.ca/trainees/

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AI4PH Certificate Program

- Certificate = 5 online courses over 2-year period; 8-hours of required time/asynchronous time
- Learners are not obliged to do 5 courses
- Target Audience: Public health professionals, trainees, AI/ML skilled professionals
- Courses will delivered by Co-PIs and program mentors

DOMAINS (Planned)

(1) Equity & Ethics - 6 courses

(2) Technical AI/ML - 12 courses

(3) Public Health, Policy - 3 courses

AI4PH Training Platform - OVERVIEW

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- Introduction to AI for Public Health
- The Tools for Data Science: Notebooks and Versioning
- Introduction to Quantitative Perspectives on Measuring Equity
- Ethics & AI for Public Health
- Natural Language Processing
- Developing and Deploying Transparent and Reproducible Algorithms for Public Health
- Public Health Data Visualization & Storytelling

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AI4PH Internships

Designed for skilled interns to be embedded within a public health or AI/data partner setting.

Interns will work on projects that contribute to their learning and professional development and foster transformative change within their host organization.

- Time-limited 3 to 6 months
- Implementation focused
- Open to trainees and working professionals

simcoe muskoka DISTRICT HEALTH UNIT

Statistics Canada / Statistique Canada

AI for Good FOUNDATION

VECTOR INSTITUTE

The Pamoja Institute

ONTARIO HIV TREATMENT NETWORK

Trillium Health Partners

Public Health Agency of Canada / Agence de la santé publique du Canada

211 Ontario

HIVE Lab Health Informatics, Visualization, and Equity

SickKids

AI4PH https://ai4ph-hrtp.ca/traineeships/

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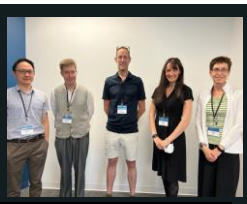
AI4PH Summer Institutes

AI4PH Summer Institutes



AI4PH PIs at McGill 2022

Summer Institute 2022 @ McGill: Analyzing Text Data

Summer Institute 2023 @ Toronto: ML & Causal Inference

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AI4PH Workshops

⇒Artificial Intelligence for Public Health: Practice Retreat
LONDON, ONTARIO – OCT 24-25, 2022

⇒Workshop on connection and understanding around national data, AI methodologies and public health
OTTAWA, ONTARIO – OCT 17-18, 2023

⇒Data and AI for Public Health and Population Health in Northern Ontario
THUNDER BAY, ONTARIO – OCT 17-18, 2023

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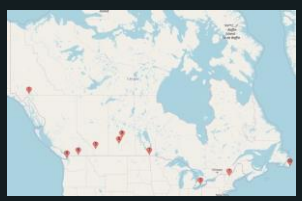
PROGRAM ELEMENTS

Community Advisory Board

GOALS

- Provide feedback to improve training programs
- Develop mechanisms to integrate community voices across the training program
- Offer trainees opportunities to learn from people with lived experience



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University of Toronto | Engineering

Dalla Lana School of Public Health

Collaborative teams

Predicting And Preventing Chronic Disease burden in populations (PREPARED): Deploying decision-support tools for the prevention of chronic diseases

Population Health Analytics Laboratory

Human Factors & Applied Statistics

DATA SCIENCES INSTITUTE

Birsen Donmez
Engineering
Human Factors

Myrtede Alfred
Engineering
Systems Engineering + Healthcare Equity

Greg A. Jamieson
Engineering
Human-computer decision-making

Laura Rosella
Public Health
Predictive Modelling

Hailey Banack
Epidemiology
Methods to address bias + chronic disease prevention

Holland Vasquez
Information Science
Human Factors

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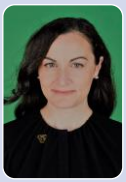
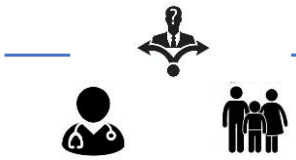
Developing the Responsible Artificial Intelligence for Health Systems (RAIHS) framework to ethically deploy Type 2 diabetes prediction models

Co-director
Dr. Laura Rosella



- **Professor**, Dalla Lana School of Public Health
- **Canada Research Chair** in Population Health Analytics and **Stephens Family Research Chair** in Community Health Trillium
- Education Lead for **The Centre for AI Research and Education and Medicine (T-CAIREM)**

Stakeholders



Co-Director
Dr. Jay Shaw

- **Assistant Professor**, Department of Physical Therapy, Temerty Faculty of Medicine
- **Canada Research Chair** in Responsible Health Innovation
- **Research Director of AI Ethics & Health**, UofT Joint Centre for Bioethics

Trillium Health Partners

Region of Peel working with you

World Health Organization

Implementation Lead
Dr. Ibukun Abejirinde

Implementation Scientist & Evaluation Specialist

Data Scientist Lead
Dr. Shion Guha

Computer Scientist & Human-centered design expert

Ethics Lead
Dr. Jennifer Gibson

Sunlife Financial Chair in Bioethics & WHO Expert Group on AI Ethics and Governance of AI

Diabetes Expert
Dr. Lorraine Lipscombe

Clinician Scientist & Director, Novo Nordisk Network for Healthy Populations

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The Future of AI x Public Health

- AI and ML allow for use of new data sources
- Allow for scale
  - Applications range from automating routine activities, surveillance, prediction, causal questions and prescriptive tasks
- To complement or enhance existing public health activities (NOT replace)

- Assessing and mitigating algorithmic bias is a priority
- Strengthening data infrastructure and data quality are critical
- AI + Public Health = AI + Equity
  - Health equity the cornerstone of a public health approach
- Potential perils of a high-risk approach in the context of population health

AI4PH

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Public health has critical expertise and perspective to shape how AI is further integrated into our society

AI4PH

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Thank you!

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Population Health Analytics Laboratory

Population Health Analytics Lab
www.pophealthanalytics.com
@PopHlthAnalytic

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https://ai4ph-hrtp.ca/
@ai4ph
/ai4ph-health-research-training-platform

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