Making Canadian Healthcare Systems “AI Ready”

What do we need to build AI-powered Trustworthy Primary Healthcare Solutions?

Sirisha Rambhatla, Ph.D.
Assistant Professor
Director, Critical ML Lab
University of Waterloo

www.sirisharambhatla.com
Future Healthcare Challenges of Canada and the World
“The number of older persons is projected to double to 1.5 billion by 2050.”
Future Healthcare Challenges of Canada and the World

World Population Ageing, 2019

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Action for Seniors report, Fall 2014

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Canada’s nursing shortage at a glance, 2022

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AI-powered Healthcare Technologies can address Urgent Healthcare Needs.
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How can we leverage it for primary healthcare?
AI for Healthcare

- Nurse Robot
- Receptionist and Administrative Support
- Online Doctor
- Body Scanning
- Health Monitoring
- Managing Medical Records
- AI-Assisted Surgery
- Drugs Creation
- Data Based Clinical Judgement

- AI for Healthcare

- A large brain graphic with interconnected nodes representing various healthcare applications.
AI for Healthcare
My AI for Healthcare Research Efforts
My AI for Healthcare Research Efforts

AI for Hepatology

AI for Physiotherapy, Surgical Candidacy and Telemedicine

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My AI for Healthcare Research Efforts

- AI for Hepatology
- AI for Physiotherapy, Surgical Candidacy and Telemedicine
- Trustworthy AI for Healthcare
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- AI for Hepatology
- AI for Physiotherapy, Surgical Candidacy and Telemedicine
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- AI for Surgical Skill Assessment
- AI for COVID

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My Research Efforts in Critical Applications
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AI for Intelligent Manufacturing

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AI for Intelligent Manufacturing

AI for Aviation Operations

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My Research Efforts in Critical Applications

- AI for Intelligent Manufacturing
- AI for Aviation Operations
- Time Series Representation Learning

Al for Intelligent Manufacturing and Planning
My Research Efforts in Critical Applications

AI for Intelligent Manufacturing
AI for Aviation Operations
Time Series Representation Learning
Transfer Learning

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AI for Intelligent Manufacturing

AI for Aviation Operations

Time Series Representation Learning

Transfer Learning

Deep Learning Explainability

AI for Intelligent Manufacturing and Planning

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- AI for Aviation Operations
- Time Series Representation Learning
- Transfer Learning
- Deep Learning Explainability
- Physics Informed Machine Learning
- Fundamental Research Threads in Deep Learning
I. AI for Forecasting Patient Outcomes in Primary Healthcare Applications
AI for Forecasting Liver Transplantation Waitlist Outcomes

Al for Healthcare
Deep Learning for Liver Transplantation
[Punchhi, Sun, Rambhatla, Bhat, American Association for the Study of Liver Diseases (AASLD), 2022] Selected for Oral Presentation
[Punchhi, Sun, Rambhatla, Bhat, Canadian Donation and Transplantation Research Program (CDTRP), 2022] Selected for Oral Presentation
[Punchhi, Sun, Rambhatla, Bhat, ILTS Annual Congress, 2022] Selected for Oral Presentation
[Punchhi, Sun, Rambhatla, Bhat, Ajmera Transplant Centre Research Day, 2022]
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![Image of liver with text: Predicting Future Trajectories of Waitlisted Patients Explaining Predicted Outcomes]

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Predicting Future Trajectories of Waitlisted Patients

Using DeepNASH to Predict NASH patient trajectories on the Liver Transplant Waitlist

1. NASH Patient Variable Extraction

   - Gender
   - Age
   - MELD

   Patient(1)
   - Gender: F
   - Age: 65
   - MELD: 42

   Patient(2)
   - Gender: M
   - Age: 72
   - MELD: 36

   Patient(3)
   - Gender: F
   - Age: 48
   - MELD: 28

2. DeepNASH Neural Network

   - Death Event Sublayer
   - Transplant Event Sublayer

3. Prediction

   - Death Event Sublayer
   - Transplant Event Sublayer

4. Clinician Insights

   - High risk of death
   - Low risk of transplant

   - High risk of transplant
   - High risk of death

   - Low risk of death
   - Low risk of transplant

   Patient(1)
   - Likely to undergo transplant soon, measures must be taken to reduce mortality.
   - Can seek living donor options.

   Patient(2)
   - Unlikely to attract an organ offer soon, measures must be taken to reduce mortality.

   Patient(3)
   - Likely stable condition, may advise patient to seek living donor options.

DeepNASH Dashboard

Upload .csv file with patient data to DeepNASH Dashboard

DeepNASH forecasts the trajectory of the NASH patient after waitlisting by predicting monthly risks of death and transplant.

Clinical interpretation

Retrospective Model Performance: Computing Event Coherence Score

\[ \mu = \frac{\mu_m \cdot \mu_n}{\mu_m + \mu_n} \]

M is the number of patient who have had the event by time t.

At actual event time, predicted risk of actual event is higher than the competing event.

Coherence \( \mu_m = 1 \)

Incoherence \( \mu_m = 0 \)

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Predicting Burn Surgical Candidacy to Assist Clinicians

First-degree burn
Second-degree burn
Third-degree burn

AI for Surgery
Predicting Burn Surgical Candidacy to Assist Clinicians

Burn Surgical Candidacy Prediction using Deep Learning
[Rambhatla*, Huang*, Trinh, Zhang, Liu, Gillenwater, AMIA Symposium, 2021]
[Huang*, Rambhatla*, Trinh, Zhang, Liu, Gillenwater, Plastic Surgery, 2021] Outstanding Presentation Award

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Multi-modal (Vision + Clinical Indicators)
Deep Learning for Surgical Candidacy

DL4Burn App for Wound Monitoring & Telemedicine

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DL4Burn App: Real-world Deployment for the Clinical Team

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II. AI for Medical Training and Skill Assessment
AI for Medical Training and Skill Assessment
AI for Medical Training and Skill Assessment

Al for Surgical Skill Assessment
AI for Medical Training and Skill Assessment

Robot Assisted Surgery Skill Assessment for Improving Surgical Outcomes

[Hung, Rambhatla, Pachauri, Sanford, Liu, American Urology Association, 2021]
[Hung, Rambhatla, Sanford, Pachauri, Vanstrum, Nguyen Liu, Journal of Surgery, 2021]
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Learning from limited labels using Transfer Learning

Label Uncertainty Detection

Al for Surgical Skill Assessment

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How Does ChatGPT Perform on the United States Medical Licensing Examination? The Implications of Large Language Models for Medical Education and Knowledge Assessment

Aidan Gilson ¹ ², Conrad W Safranek ¹, Thomas Huang ², Vimig Socrates ¹ ³, Ling Chi ¹, Richard Andrew Taylor # ¹ ², David Chartash # ¹ ⁴

Affiliations + expand

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Large Language Models for Training and Patient Support

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Are Large Language Models (LLMs) ready to be used for training and helping patients?
New wave of misinformation in the era of ChatGPT
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Self-Diagnosis and Large Language Models (LLMs): A New Front for Medical Misinformation
[Barnard, Sittert, Rambhatla, Under Review, 2023]

Critical Analysis of LLMs for Healthcare

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We find that ChatGPT is optimistic when there is higher risk, while it is more cautious in cases where that optimism is warranted!
III. Lessons from COVID-19 Pandemic
AI for COVID-19
AI for COVID-19

Predicting Spatiotemporal Risk Scores using High Resolution Mobility Data

AI for COVID-19

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[Sharma, Seo, Meng, Rambhatla, Liu, 2020]

Analyzing COVID-19 Misinformation in Twitter Conversations

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Misinformation Spread

GOP blocking coronavirus bill — because it limits how much drugmakers can charge for a vaccine https://t.co/ekkvU7QquQ

political-clickbait
AI for COVID-19

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[Misinformation Spread


Modeling Epidemic Spread under Intervention Policies


Predicting the effect of interventions

California

Florida

Texas
Canada’s nursing shortage at a glance, 2022

Canada’s nursing shortage, pre-pandemic

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People 'dying unnecessarily' because of racial bias in Canada's health-care system, researcher says

N.W.T. Health Minister Glen Abernethy says department plans cultural sensitivity training

Emily Blake • CBC News • Posted: Jul 03, 2018 10:34 AM EDT | Last Updated: July 3, 2018

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BUT

they can also Reinforce Existing Biases
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AND
there is no way to know the impact of these protected attributes if we don’t adequately record them!
IV. Trustworthy and Fair AI Modelling in Healthcare
Trustworthy and Fair AI Modelling in Healthcare
Whose Health Matters in Healthcare Models? Understanding Data Bias for Healthcare Equity
Trustworthy and Fair AI Modelling in Healthcare

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Closer look at the MIMIC III/IV Dataset: the most popular healthcare dataset

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Where does MIMIC Dataset come from?
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Where is MIMIC being used?

Data Matters: Models trained on data naively may not work well on all demographics or in new contexts!

Who gets Admitted in Emergency Department (ED)?

In-hospital Mortality

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So, what needs to happen to assist healthcare workers and make Canada “AI Ready”? 
Steps to make Canada “AI Ready”
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• **All data is not created equal.** Results on US data may not be directly transferable. We need to leverage Canadian data to make an impact.
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Recommendations

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- **Need to collect demographic information.** AI/ML models learn from historical data, and can reinforce any past biases. We need to collect demographic information to understand these biases, and use these to improve predictions while preserving privacy. We can’t fix what we don’t know!
Steps to make Canada “AI Ready”

Recommendations
Steps to make Canada “AI Ready”

- **ML infrastructure**: AI/ML model training requires specialized compute, and researchers and hospital need strategic support in this area; It is impractical that everyone builds this infrastructure independently.
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- **Sharing is caring.** Likewise, hospitals will have to come together and share their data to power these models. Otherwise silos created by data inequity will lead to worse outcomes for our far-off communities who need these interventions the most!
IT'S NOT JUST ME!
Conversations in the context of managing health data have already set the stage!
Challenges outlined by the pan-Canadian Health Data Strategy EAG
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The pan-Canadian Health Data Strategy: Expert Advisory Group Reports and summaries

Chair

▼ Dr. Vivek Goel

Health Data Champion, University of Waterloo

Reports

Expert Advisory Group Report 3: Toward a world-class health data system (PDF Version)
Expert Advisory Group Report 2: Building Canada’s Health Data Foundation (PDF Version)
Expert Advisory Group Report 1: Charting a Path toward Ambition (PDF Version)
Challenges outlined by the pan-Canadian Health Data Strategy EAG

**THE PUBLIC** are frustrated by their lack of access to their personal health information, requiring access to dozens of online portals to achieve only a partial view of their health records with no insight into how they can take action to improve their own health. They are also challenged to understand how well the health sector is working and how to hold decision-makers accountable for its improvement.

**FIRST NATIONS, INUIT, AND MÉTIS** suffer from health systems that perpetuate and contribute to existing structured social inequities and have difficulty exercising their right to self-determination. Also applies to many diverse communities across Canada.

**PUBLIC HEALTH** does not have ready access to all of the data it needs to provide timely, precise, and actionable insights, in particular during public health emergencies.
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- THE PUBLIC are frustrated by their lack of access to their personal health information, requiring access to dozens of online portals to achieve only a partial view of their health records with no insight into how they can take action to improve their own health. They are also challenged to understand how well the health sector is working and how to hold decision-makers accountable for its improvement.

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The pan-Canadian Health Data Strategy: Expert Advisory Group Reports and summaries

Chair

Dr. Vivek Goel
Health Data Champion, University of Waterloo

Reports

- Expert Advisory Group Report 3: Toward a world-class health data system (PDF Version)
- Expert Advisory Group Report 2: Building Canada’s Health Data Foundation (PDF Version)
- Expert Advisory Group Report 1: Charting a Path toward Ambition (PDF Version)

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To learn more about this 2022 report and its recommendations:
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