A presentation for

Statistics Canada | Statistique Canada

Santé Canada | Health Canada

May 5, 2023

CYBER SECURITY AND PRIVACY INSTITUTE
UNIVERSITY OF WATERLOO

WATERLOO.AI
WATERLOO ARTIFICIAL INTELLIGENCE INSTITUTE

WISA Waterloo Institute for Sustainable Aeronautics

Critical ML

Cybersecurity, Privacy, and Artificial Intelligence in Health Data Advancements and Challenges Conference

Sirisha Rambhatla, Ph.D.

Assistant Professor
Director, Critical ML Lab
University of Waterloo

www.sirisharambhatla.com

Making Canadian Healthcare Systems "AI Ready"

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

UNIVERSITY OF WATERLOO | FACULTY OF ENGINEERING Department of Management Sciences | FACULTY OF MATHEMATICS DAVID R. CHERITON SCHOOL OF COMPUTER SCIENCE | FACULTY OF ENGINEERING Department of Systems Design Engineering

Future Healthcare Challenges of Canada and the World

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United Nations | Department of Economic and Social Affairs

World Population Ageing, 2019

“The number of older persons is projected to double to 1.5 billion by 2050.”

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In 2014, about 15% of Canadians were above the age of 65, this percentage is set to rise to 25% by 2040.

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In 2014, about 15% of Canadians were above the age of 65, this percentage is set to rise to 25% by 2040.

CFNU | CANADIAN FEDERATION OF NURSES UNIONS

Canada's nursing shortage at a glance, 2022

The nursing shortage, pre-pandemic

Even as our population ages and our health needs become more acute, growth in the regulated health workforce has largely remained stagnant.

A 2018 analysis predicted a shortage of 117,600 nurses in Canada by 2030 (Scheffler & Arnold, 2018). According to 2020 data, a third of registered nurses who provide direct care are 50 or older and nearing retirement (Registered Nurses' Association of Ontario, 2021). A 2019 survey of nurses conducted by the CFNU with

AI-powered Healthcare Technologies can address Urgent Healthcare Needs

AI-powered Healthcare Technologies can address Urgent Healthcare Needs

How can we leverage it for primary healthcare?


AI for Healthcare
NURSE ROBOT
RECEPTIONIST AND ADMINISTRATIVE SUPPORT
MANAGING MEDICAL RECORDS
HEALTH MONITORING
ONLINE DOCTOR
AI-ASSISTED SURGERY
BODY SCANNING
DATA BASED CLINICAL JUDGEMENT
DRUGS CREATION


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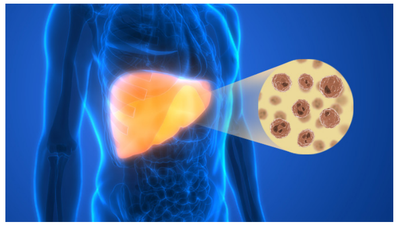
My AI for Healthcare Research Efforts

My AI for Healthcare Research Efforts

UHN



AI for Hepatology

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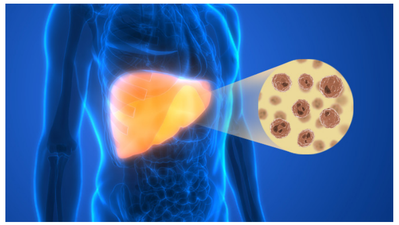

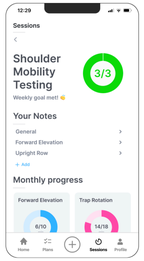

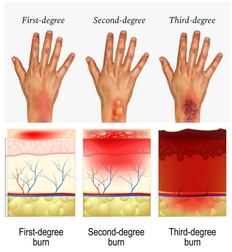

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Critical ML

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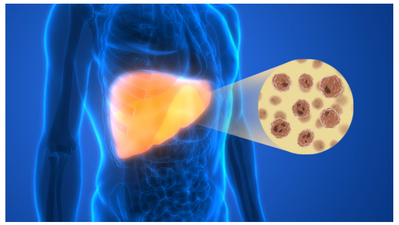

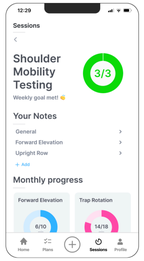

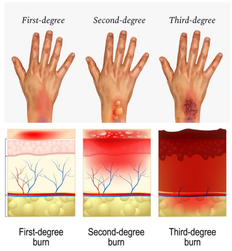

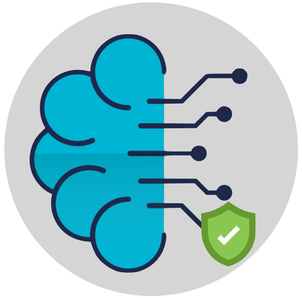

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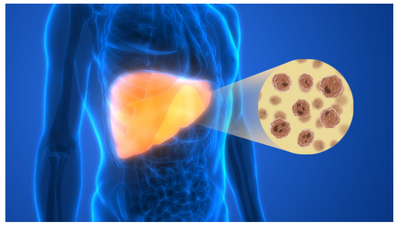
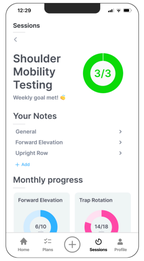
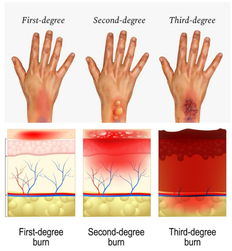
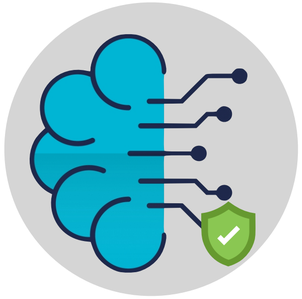
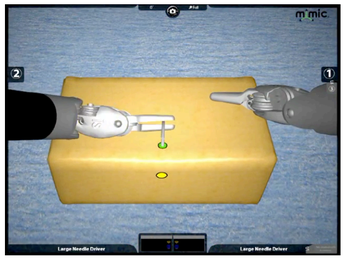
Keck School of Medicine of USC











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Trustworthy AI for Healthcare

AI for Surgical Skill Assessment

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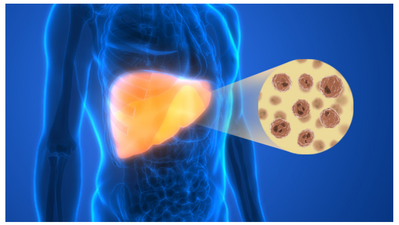
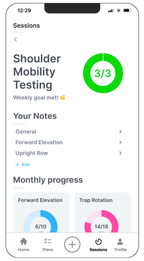
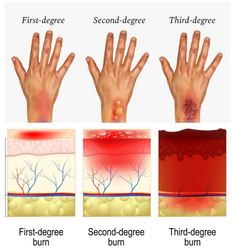
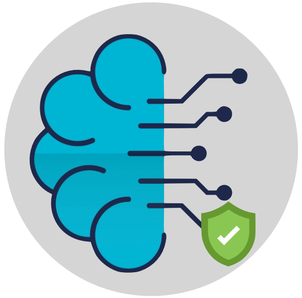
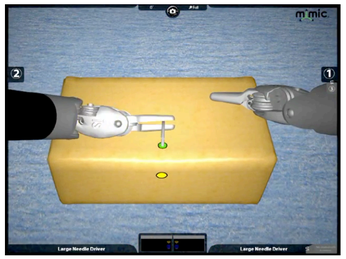
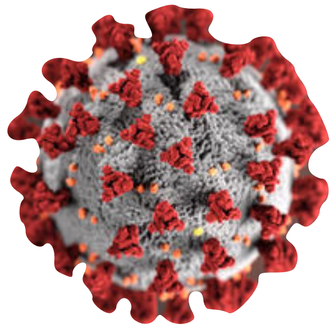












AI for Hepatology

AI for Physiotherapy, Surgical Candidacy and Telemedicine

Trustworthy AI for Healthcare

AI for Surgical Skill Assessment

AI for COVID

Critical ML

My Research Efforts in Critical Applications

My Research Efforts in Critical Applications

AI for Intelligent Manufacturing

My Research Efforts in Critical Applications

AI for Intelligent Manufacturing

AI for Aviation Operations

My Research Efforts in Critical Applications

AI for Intelligent Manufacturing

AI for Aviation Operations

AI for Intelligent Manufacturing and Planning

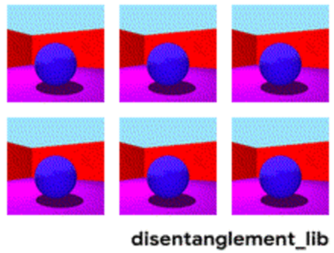
My Research Efforts in Critical Applications

NISSAN

CYBER SECURITY INSTITUTE AND PRIVACY UNIVERSITY OF WATERLOO

NAVBLUE AN AIRBUS COMPANY

UNIVERSITY OF WATERLOO



AI for Intelligent Manufacturing

AI for Aviation Operations

Time Series Representation Learning

AI for Intelligent Manufacturing and Planning

Critical ML

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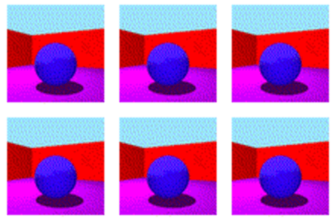

Time Series Representation Learning

Transfer Learning

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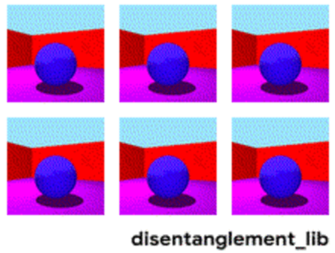
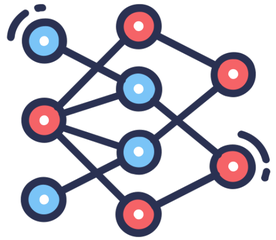


Time Series Representation Learning

University of Waterloo

Transfer Learning

USC University of Southern California



Deep Learning Explainability

AI for Intelligent Manufacturing and Planning

My Research Efforts in Critical Applications

NISSAN | CYBER SECURITY INSTITUTE AND PRIVACY, UNIVERSITY OF WATERLOO

AI for Intelligent Manufacturing

NAVBLUE, AN AIRBUS COMPANY

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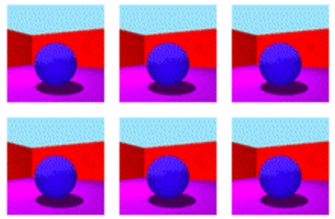
UNIVERSITY OF WATERLOO



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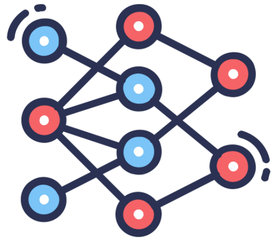

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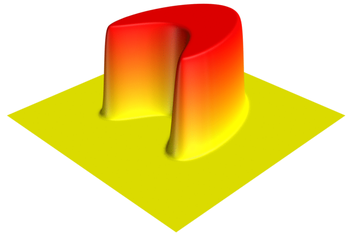

Physics Informed Machine Learning

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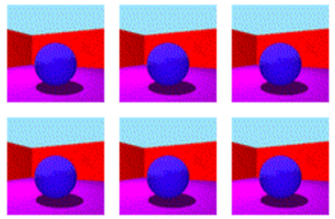

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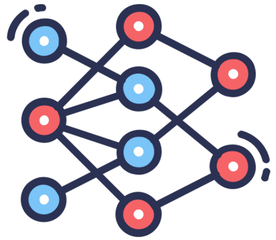

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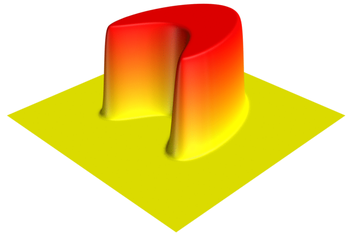


Physics Informed Machine Learning

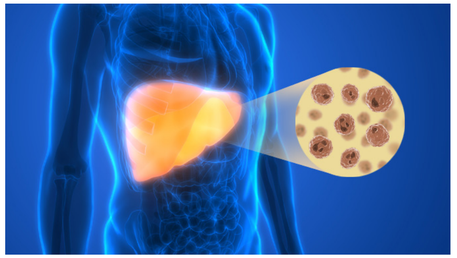
AI for Intelligent Manufacturing and Planning

Fundamental Research Threads in Deep Learning

Critical ML

I. AI for Forecasting Patient Outcomes in Primary Healthcare Applications

AI for Forecasting Liver Transplantation Waitlist Outcomes



AI for Healthcare

AI for Forecasting Liver Transplantation Waitlist Outcomes

Deep Learning for Liver Transplantation

[Punchhi, Sun, **Rambhatla**, Bhat, American Association for the Study of Liver Diseases (AASLD), 2022] **Selected for Oral Presentation**
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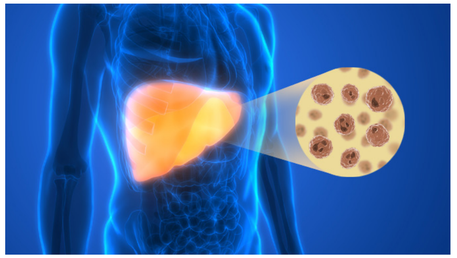

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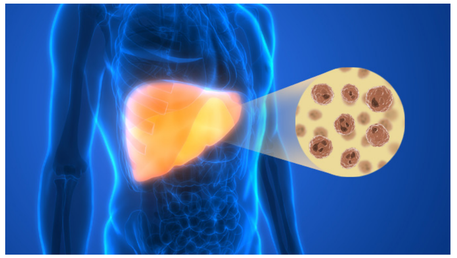

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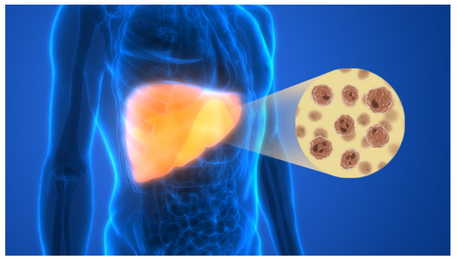
Predicting Future Trajectories of Waitlisted Patients

Explaining Predicted Outcomes

AI for Forecasting Liver Transplantation Waitlist Outcomes



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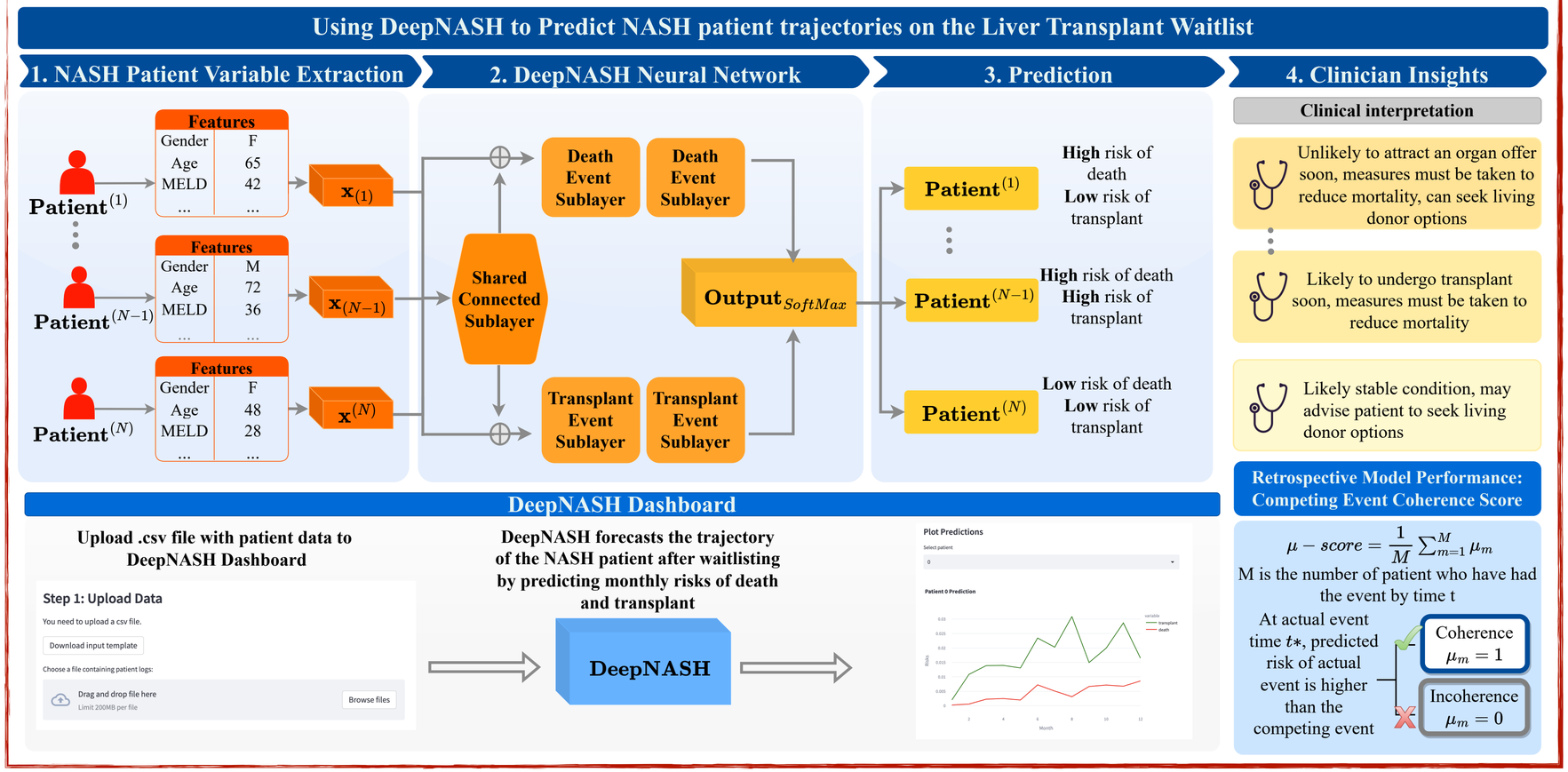
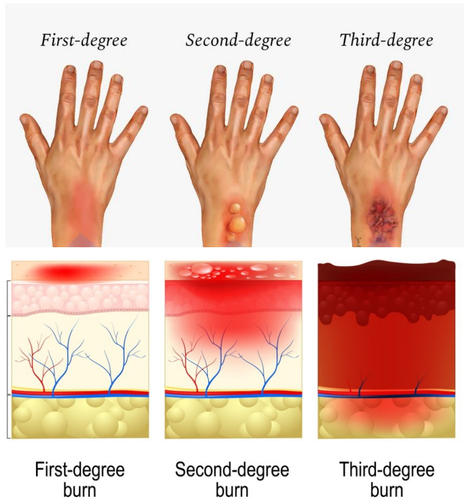
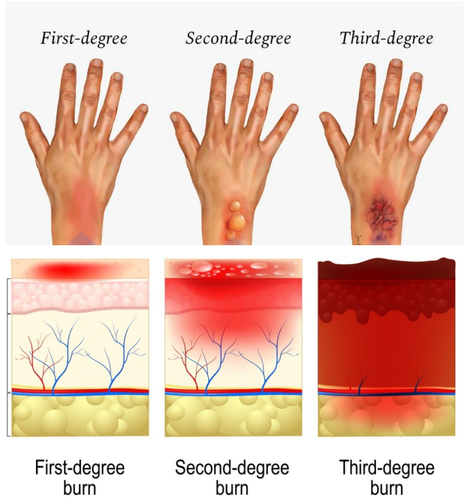


Predicting Burn Surgical Candidacy to Assist Clinicians



AI for Surgery

Predicting Burn Surgical Candidacy to Assist Clinicians

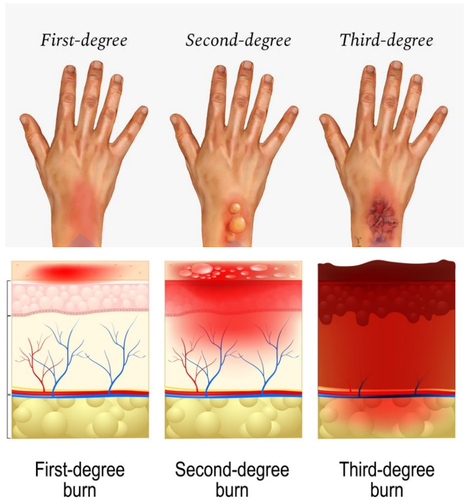


AI for Surgery

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**

Predicting Burn Surgical Candidacy to Assist Clinicians



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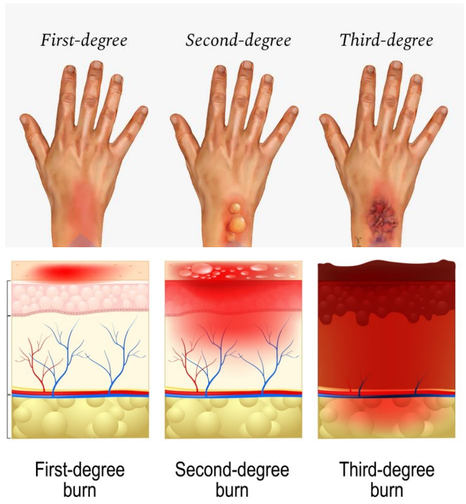
Multi-modal (Vision + Clinical Indicators) Deep Learning for Surgical Candidacy

DL4Burn App for Wound Monitoring & Telemedicine

Predicting Burn Surgical Candidacy to Assist Clinicians



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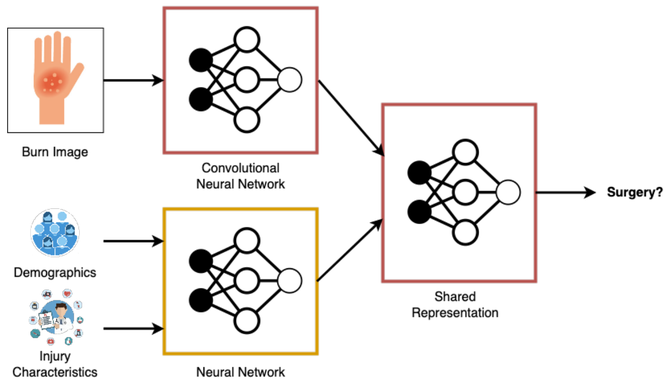
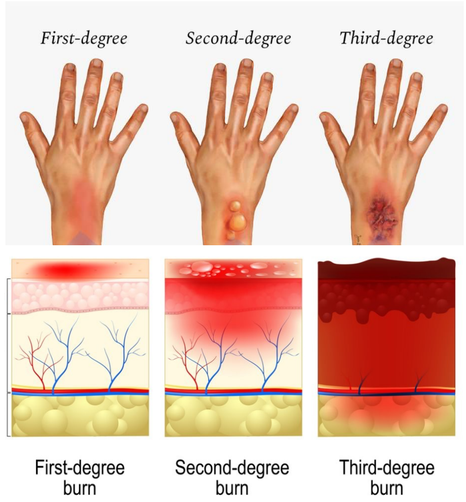
23 to 88% improvement over surgeons!



Predicting Burn Surgical Candidacy to Assist Clinicians



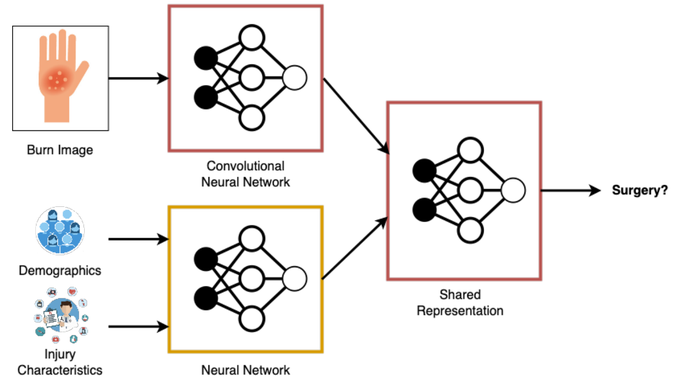
AI for Surgery

Burn Surgical Candidacy Prediction using Deep Learning

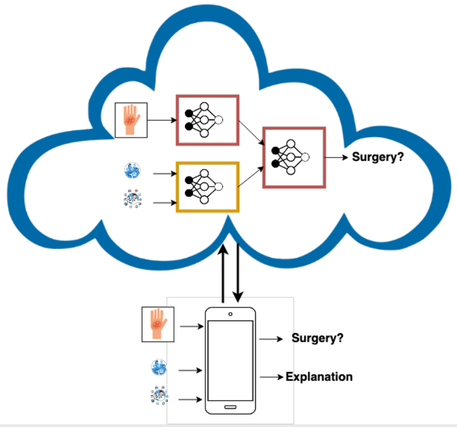
[**Rambhatla***, Huang*, Trinh, Zhang, Liu, Gillenwater, *AMIA Symposium*, 2021]
[Huang*, **Rambhatla***, Trinh, Zhang, Liu, Gillenwater, *Plastic Surgery*, 2021] **Outstanding Presentation Award**

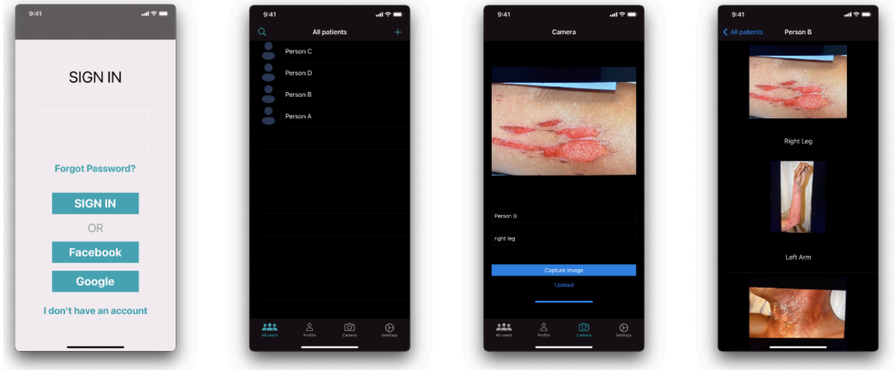
Multi-modal (Vision + Clinical Indicators) Deep Learning for Surgical Candidacy

DL4Burn App for Wound Monitoring & Telemedicine



23 to 88% improvement over surgeons!

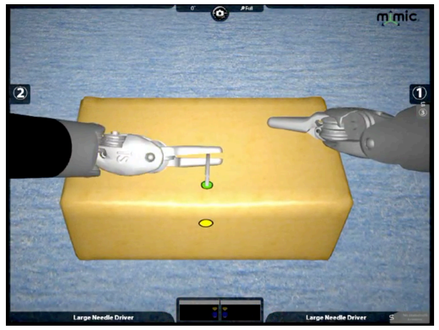




DL4Burn App: Real-world Deployment for the Clinical Team

II. AI for Medical Training and Skill Assessment

AI for Medical Training and Skill Assessment



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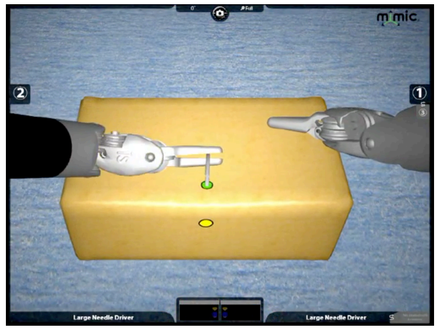

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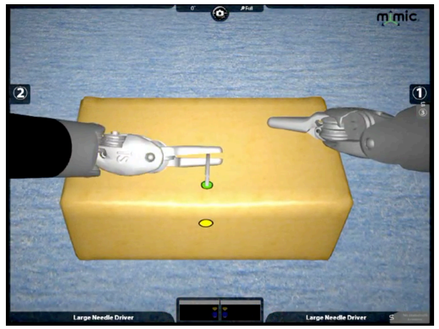

AI for Surgical Skill Assessment

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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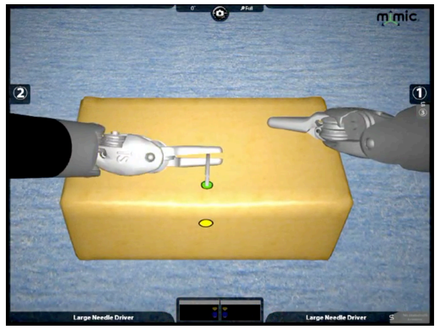

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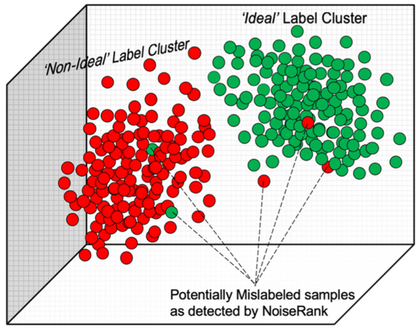
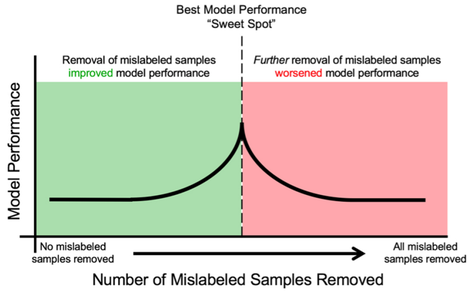
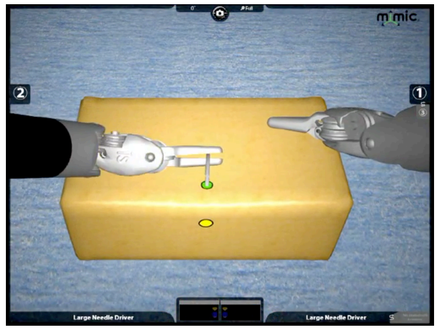




Label Uncertainty Detection

AI for Medical Training and Skill Assessment



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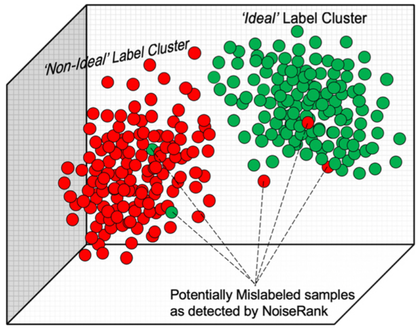

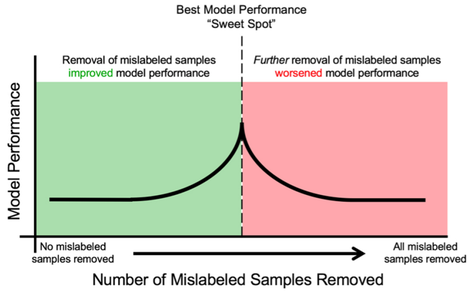

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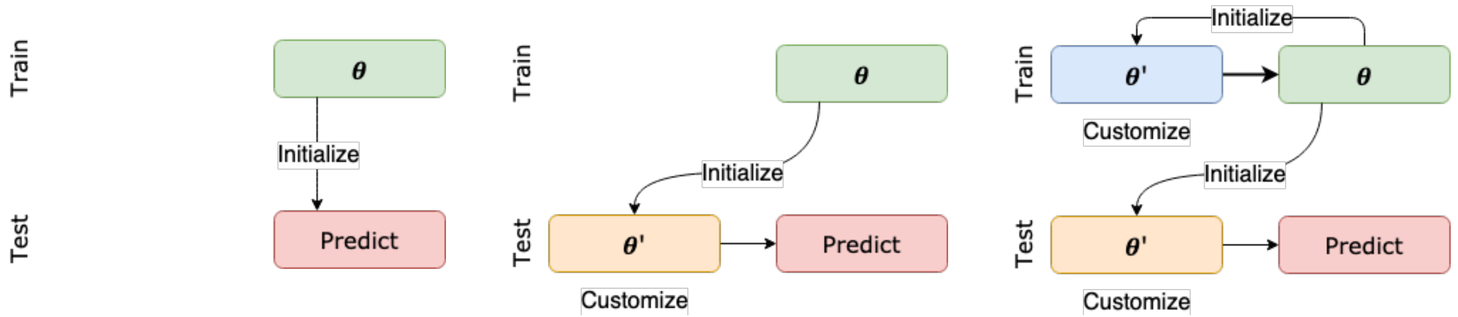

(a) No-Customization (b) Fine-Tune (c) Meta Learning

Learning from limited labels using Transfer Learning

Large Language Models for Training and Patient Support

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JMIR Med Educ. 2023 Feb 8;9:e45312. doi: 10.2196/45312.

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Affiliations + expand

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Original Investigation ONLINE FIRST FREE

April 28, 2023

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John W. Ayers, PhD, MA[1,2]; Adam Poliak, PhD[3]; Mark Dredze, PhD[4]; et al

» Author Affiliations | Article Information

JAMA Intern Med. Published online April 28, 2023. doi:10.1001/jamainternmed.2023.1838

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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

Critical Analysis of
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[Barnard, Sittert, **Rambhatla**, *Under Review,* 2023]

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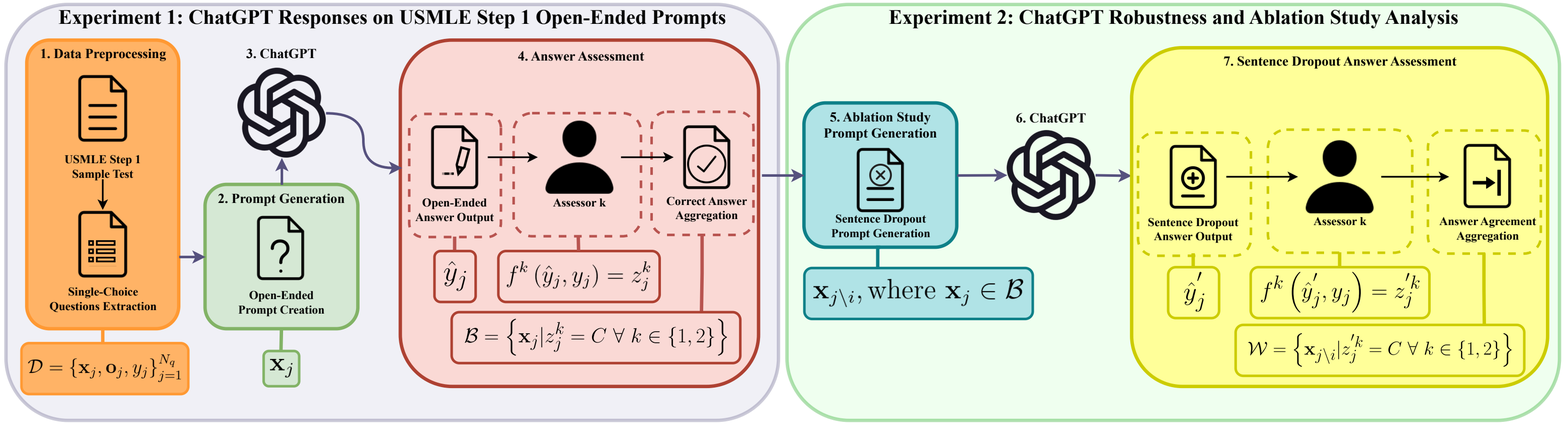

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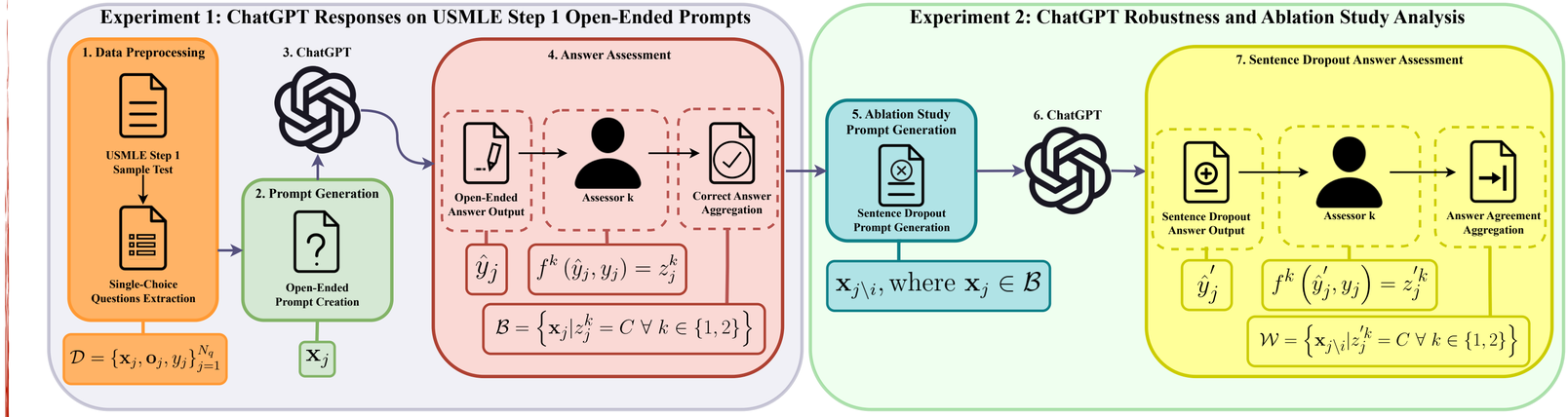

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Putting Claims of LLMs passing Medical Exams to Test

Sensitivity Analysis

Asking ChatGPT to Assess its Own Answers

UNIVERSITY OF WATERLOO

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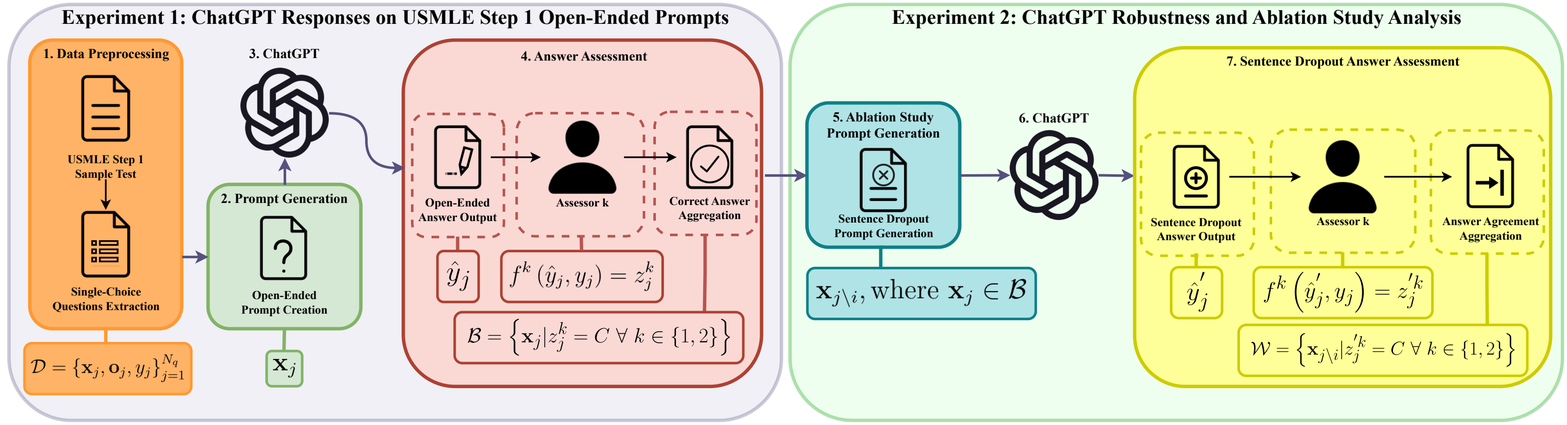

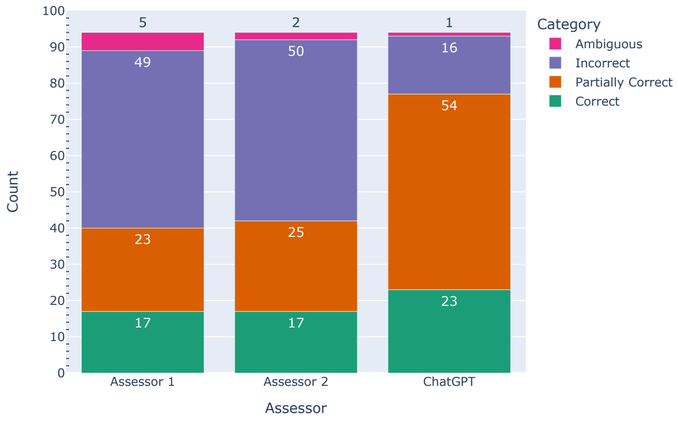

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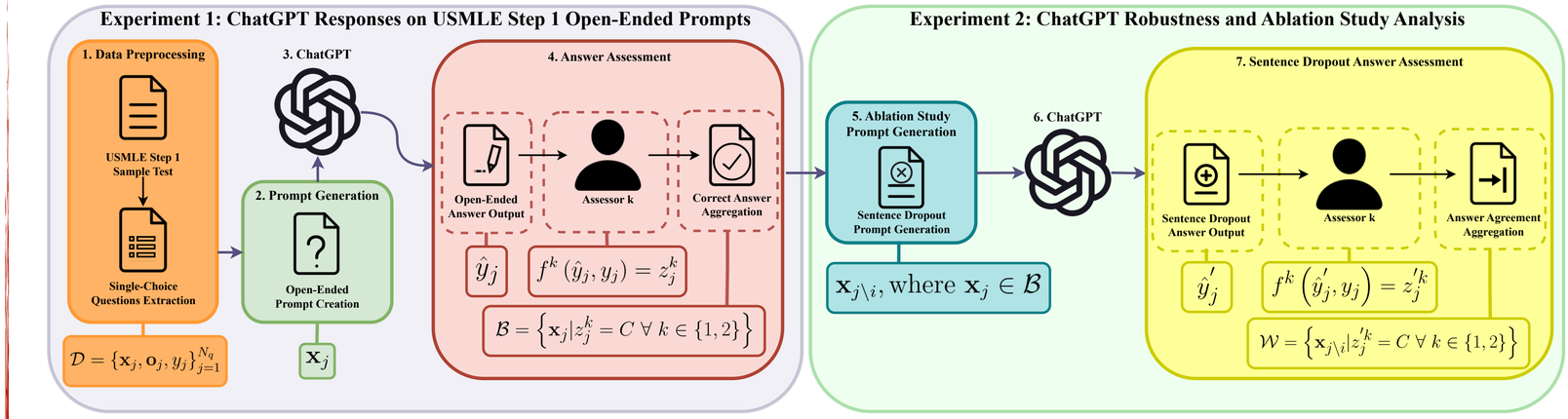

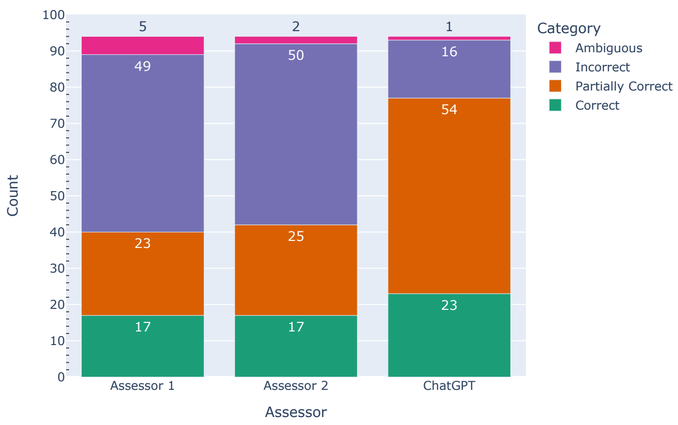

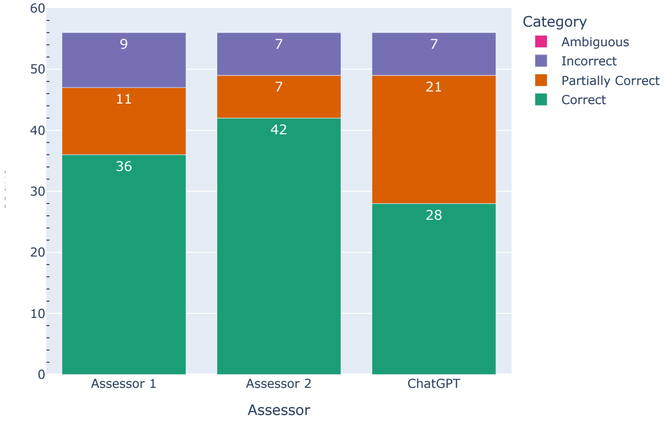

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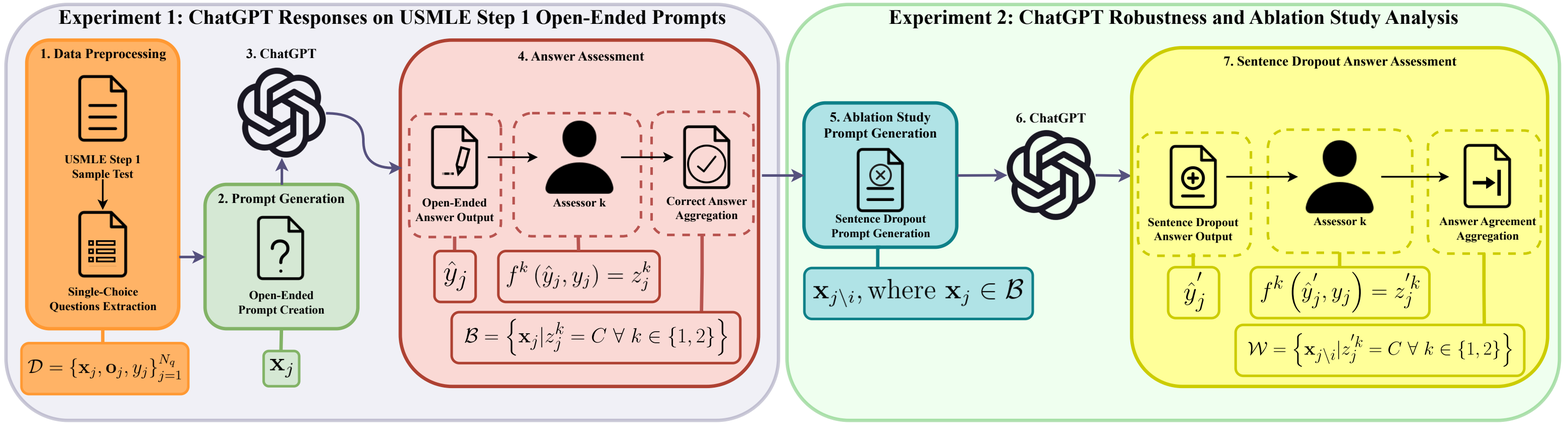

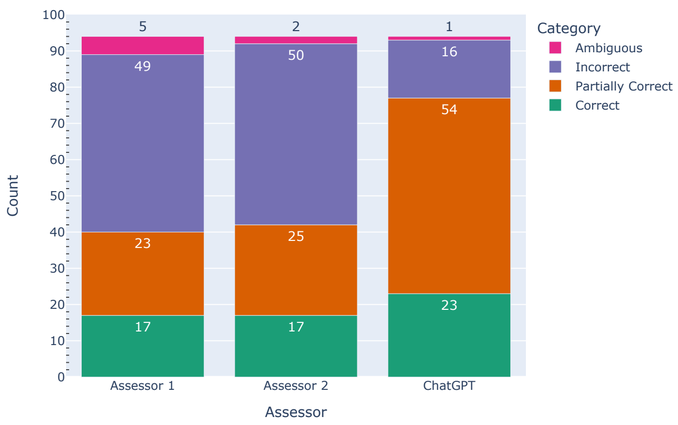

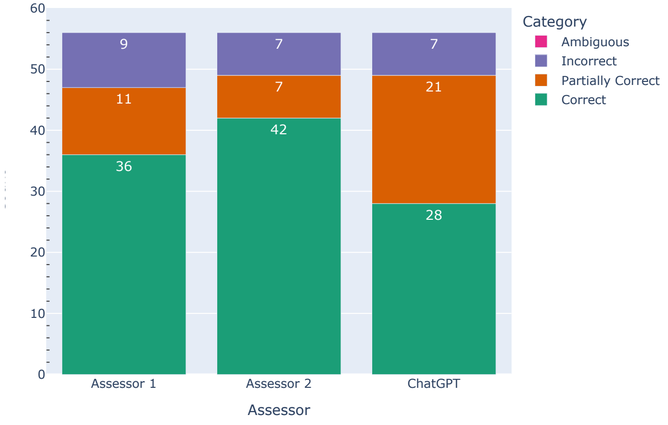

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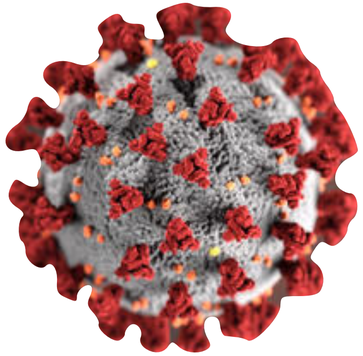
We find that ChatGPT is optimistic when there is higher risk, while it is more cautious in cases where that optimism is warranted!

III. Lessons from COVID-19 Pandemic

AI for COVID-19



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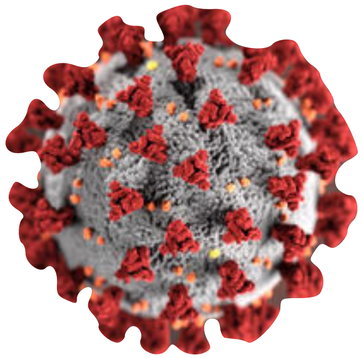

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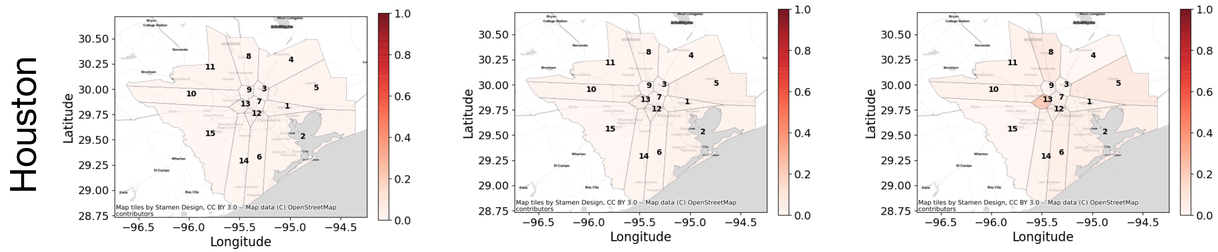
Predicting Spatiotemporal Risk Scores using High Resolution Mobility Data

[**Rambhatla**, Zeighami, K. Shahabi, C.Shahabi, Liu, ACM Transactions on Spatial Algorithms and Systems, 2021]



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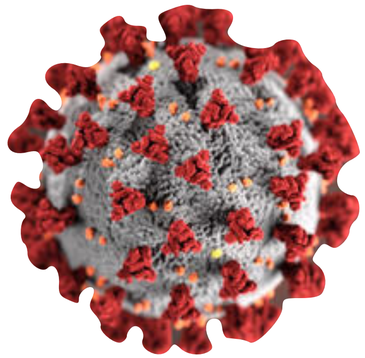

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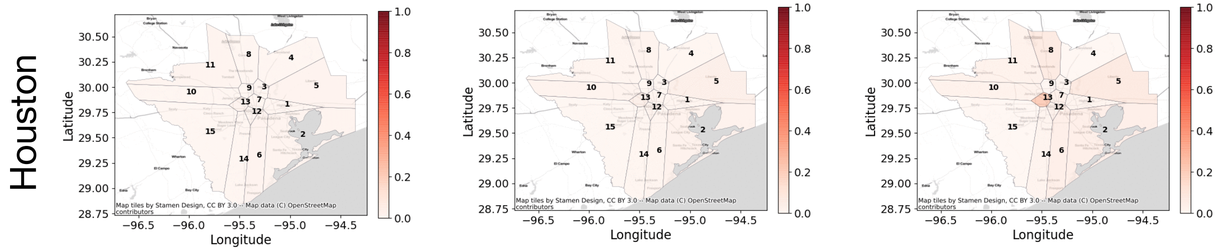
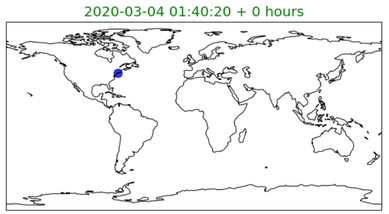


Analyzing COVID-19 Misinformation in Twitter Conversations

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

Misinformation Spread



political-clickbait

GOP blocking coronavirus bill — because it limits how much drugmakers can charge for a vaccine https://t.co/elkvU7QquQ

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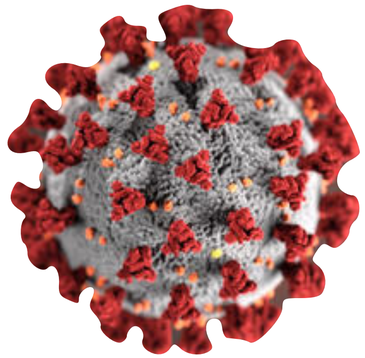

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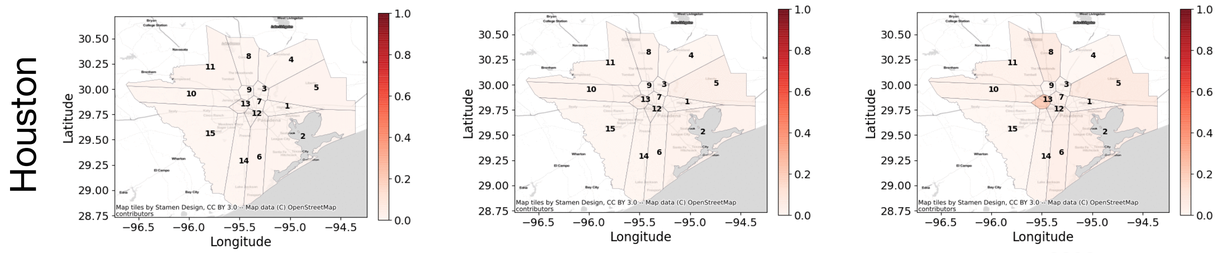

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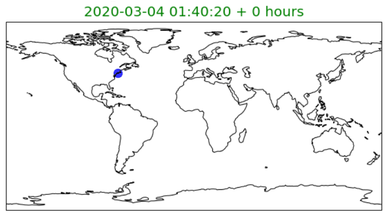

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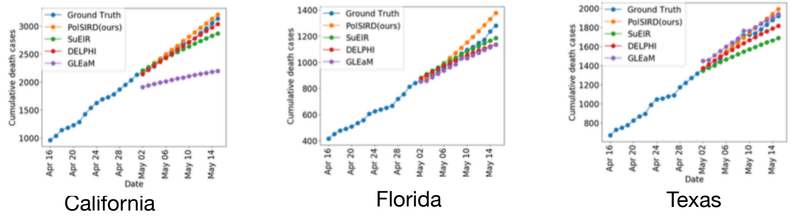
Modeling Epidemic Spread under Intervention Policies

[Kamra, Zhang, **Rambhatla**, Meng, Liu, Journal of Healthcare Informatics 2020]

Predicting the effect of interventions



Revisiting the Future Healthcare Challenges of Canada and the World…

United Nations | Department of Economic and Social Affairs

World Population Ageing, 2019

"The number of older persons is projected to double to 1.5 billion by 2050."

Government of Canada | Gouvernement du Canada

Action for Seniors report, Fall 2014

In 2014, about 15% of Canadians were above the age of 65, this percentage is set to rise to 25% by 2040.

CFNU CANADIAN FEDERATION OF NURSES UNIONS

Canada's nursing shortage at a glance, 2022

The nursing shortage, pre-pandemic

Even as our population ages and our health needs become more acute, growth in the regulated health workforce has largely remained stagnant.

A 2018 analysis predicted a shortage of 117,600 nurses in Canada by 2030 (Scheffler & Arnold, 2018). According to 2020 data, a third of registered nurses who provide direct care are 50 or older and nearing retirement (Registered Nurses' Association of Ontario, 2021). A 2019 survey of nurses conducted by the CFNU with

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

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NADIAN FEDERATION NURSES UNIONS

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ELSEVIER

Canadian Journal of Cardiology

Volume 38, Issue 12, December 2022, Pages 1865-1880

Review

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Isabel Kim MD [a], Thalia S. Field MD, MHSc [b], Darryl Wan MD [c], Karin Humphries MBA, DSc [a], Tara Sedlak MD, FRCPC, MBA [a]

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CJC Canadian Journal of Cardiology

CFNU

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Canada's nursing shortage at a glance, 2022

The Nursing shortage, pre-pandemic

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IV. Trustworthy and Fair AI Modelling in Healthcare

Trustworthy and Fair AI Modelling in Healthcare

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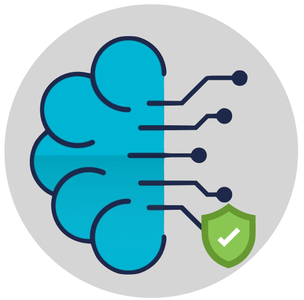

Trustworthy AI for Healthcare

Critical ML

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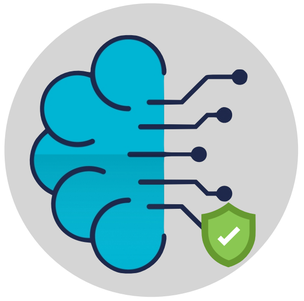

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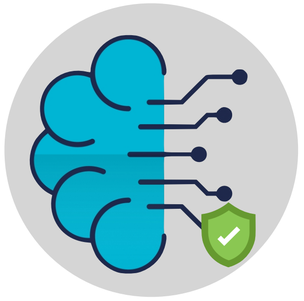

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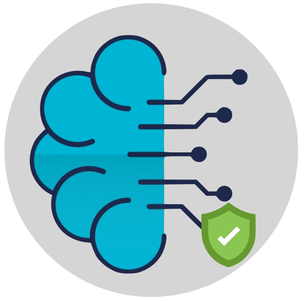

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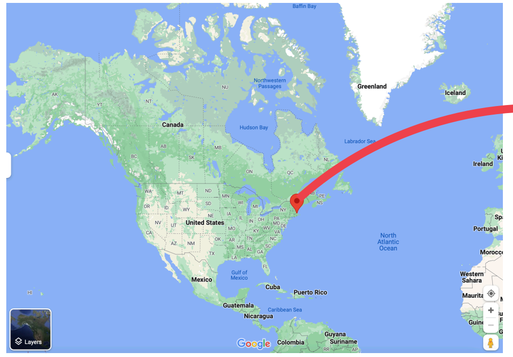

Beth Israel Deaconess Medical Center Emergency Room

Boston, MA

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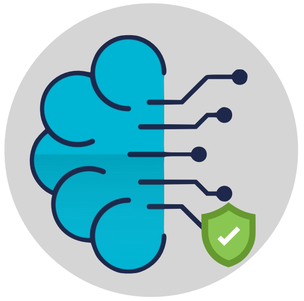

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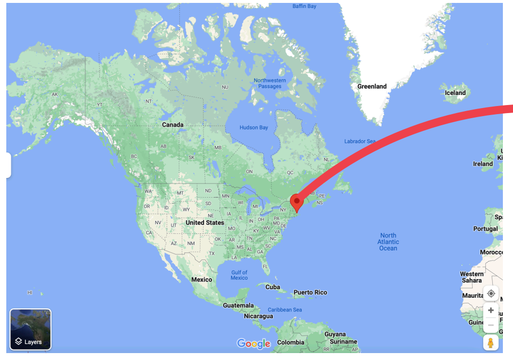

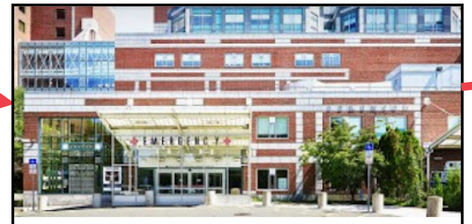

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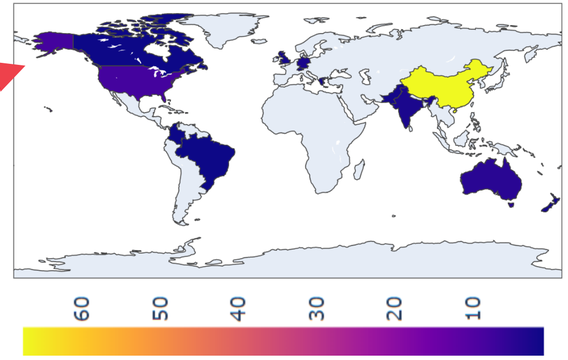

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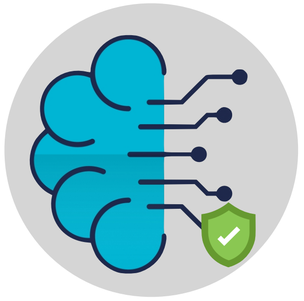

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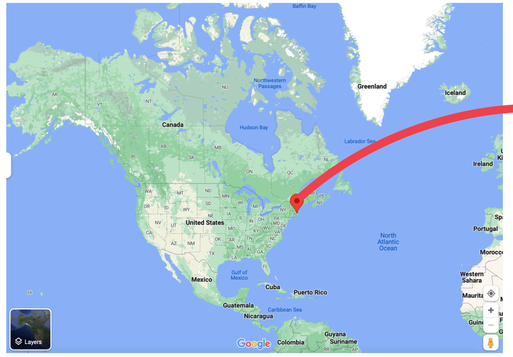

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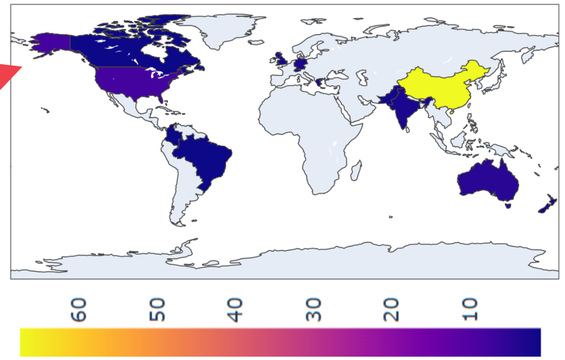

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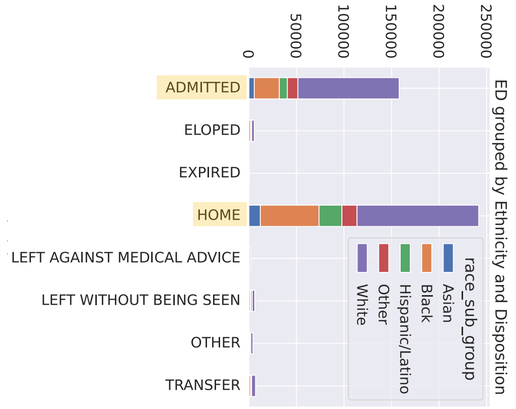

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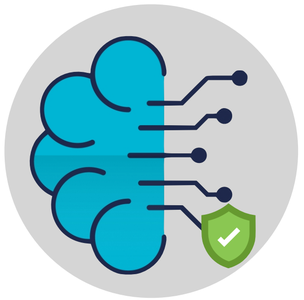

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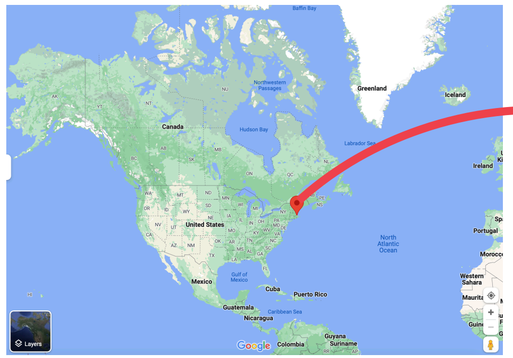

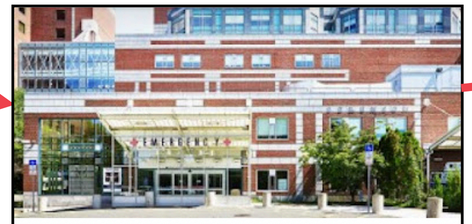

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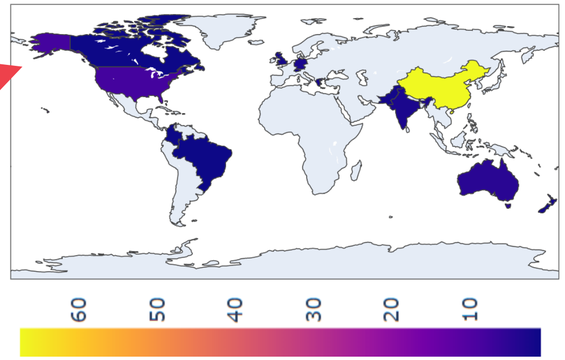

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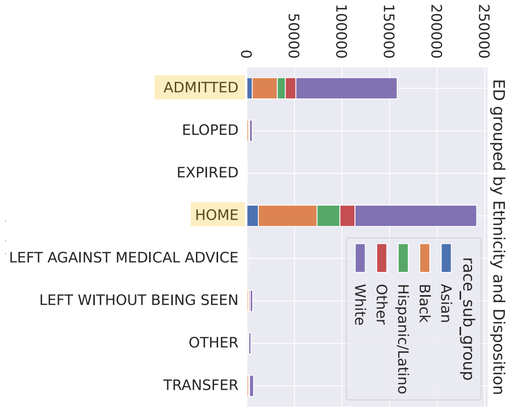

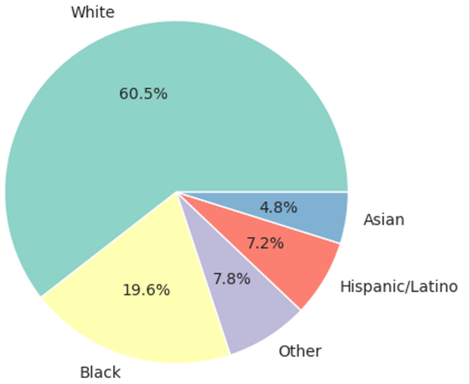

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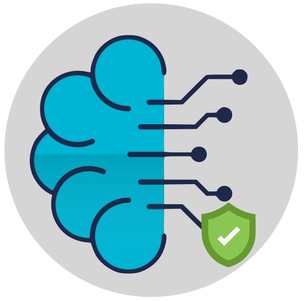

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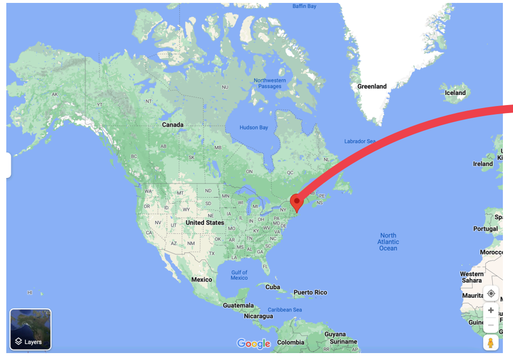

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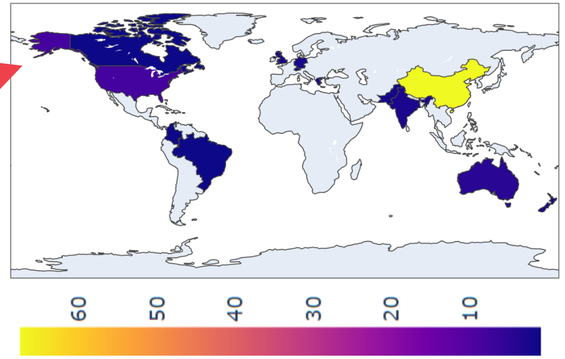

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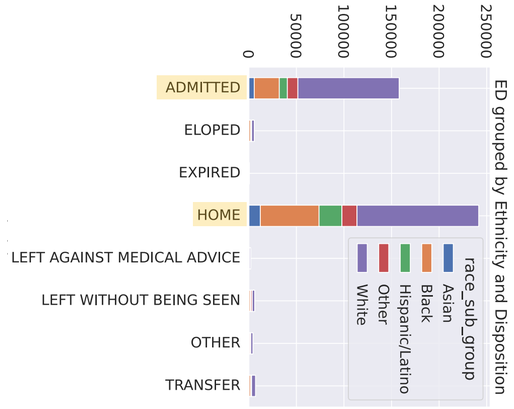

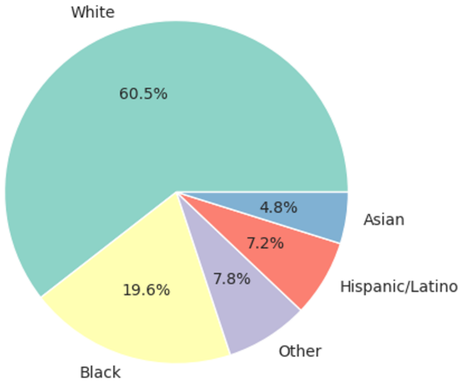

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Data Matters: Models trained on data naively may not work well on all demographics or in new contexts!

Critical ML

So, what needs to happen to assist healthcare workers and make Canada “AI Ready” ?

Steps to make Canada “AI Ready”

Recommendations

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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!


Critical ML


IT'S NOT JUST ME!
imgflip.com

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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Government of Canada | Gouvernement du Canada

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)

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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.

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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.

CLINICIANS are challenged to incorporate new requirements for data collection while receiving few or no benefits in reduced workload nor seeing better outcomes for their patients, contributing to burnout.

HEALTH SECTOR MANAGEMENT is frustrated and uncertain as to how to address data shortfalls despite serial attempts to do so, leading to below average results in health outcomes and above average costs compared to other G7 countries, to the extent these metrics can be reliably compared.

RESEARCHERS spend significant time obtaining data access and sharing approvals and are unable to complete timely and appropriately powered studies to improve the health of Canadians.

INNOVATORS have great ideas that cannot be implemented or scaled due to fragmentation in the health data ecosystem.

Government of Canada / Gouvernement du Canada

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)

To learn more about this 2022 report and its recommendations:

https://www.canada.ca/en/public-health/corporate/mandate/about-agency/external-advisory-bodies/list/pan-canadian-health-data-strategy-reports-summaries.html

Tackle urgent future challenges and make Canadian Healthcare “AI Ready”

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Human-Centered AI

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May 5, 2023

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Thank You!

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