


Polytechnic Showcase 2025

Stress and Resilience: Harnessing Wearable Technology and Machine Learning for First Responders

National Defence | Défense nationale

Canada

DRDC | RDDC

ALGONQUIN COLLEGE

Session Agenda

- Applied Research at Algonquin College
- Research Development Institute
- Canadian Safety and Security Program: Micro-Net
- Our partners and team
- Why are we doing this work?
- How are we doing this work?
- What other projects do we have on the go?
- Time for questions and discussion

Algonquin College's Purpose

MISSION

To transform hopes and dreams into lifelong success.

VISION

To be a global leader in personalized, digitally connected, experiential learning.

OUR VALUES

CARING

We have a sincere and compassionate interest in the well-being of the individual.

LEARNING

We believe in the pursuit of knowledge, personal growth and development.

INTEGRITY

We believe in trust, honesty and fairness in all relationships and transactions.

RESPECT

We value the dignity and uniqueness of the individual. We value the equity and diversity in our community.

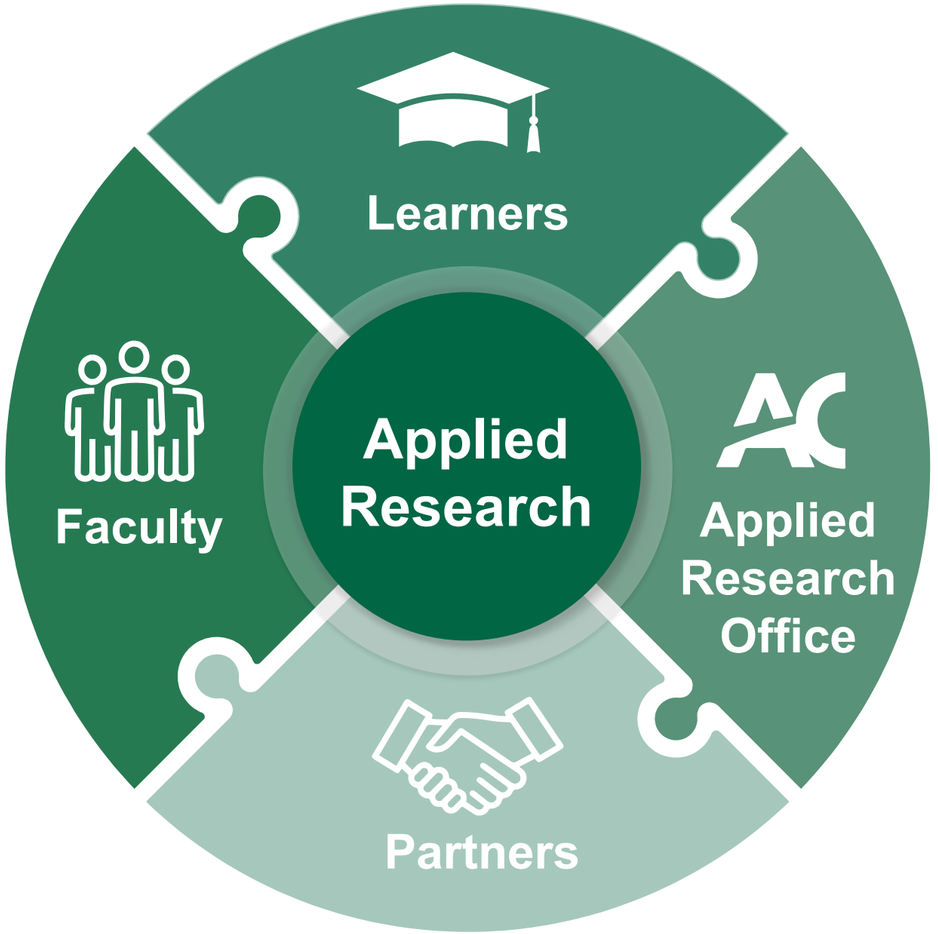
Algonquin College Research Focus Areas

Algonquin College's **Research Focus Areas** are built upon our core strengths and are closely aligned with our academic mission.

Our **Digital Technologies Centre** offers comprehensive capabilities that support and enhance these Research Focus Areas.

Applied Research Office

The Applied Research Office brings together Algonquin College's talented professors and students with community businesses, industry, and organizations to collaborate on applied research projects.



Research Development Institute (RDI)

The goal of RDI is to enhance the College's research expertise and foster a research culture by utilizing the skills of our full-time faculty.

1. Support highly strategic research for and with industry or community partners
2. Grow the applied research capacity

Research Centres and Labs

Research Centres/Labs have been established in specific areas in collaboration with the Algonquin Academic Missions Areas.

Victimology Research Centre

Social Innovation Lab

Digital Technologies Centre

Human-Centered Design Lab

Green Supply Chain and Sustainability Research Lab

ALGONQUIN COLLEGE
Applied Research

CSSP Micro-Net

Stress and Resilience: Harnessing Wearable Technology and Machine Learning with First Responders

Canadian Safety and Security Program

The Centre for Security Science (CSS) manages the Canadian Safety & Security Program (CSSP) in partnership with Public Safety Canada (PSC).

The CSSP is a federally-funded program fostering innovative S&T advancements at federal, provincial, territorial, and municipal levels of government that contribute to the safety and security of Canadians.

Launched in 2012, the CSSP's funding mechanisms deliver high impact S&T innovations and research that address key safety and security challenges.

CSSP engages government departments to meet their safety and security requirements with S&T solutions in collaboration with industry and/or academia.

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Innovation Networks – Micro-nets

- Funding mechanism: Non-repayable contribution of up to $1.5M
- Timeline: 36 months
- Composition:
  - Multidisciplinary
  - At least three separate organizations, one must be a Canadian University
- Initial recipient: Canadian University

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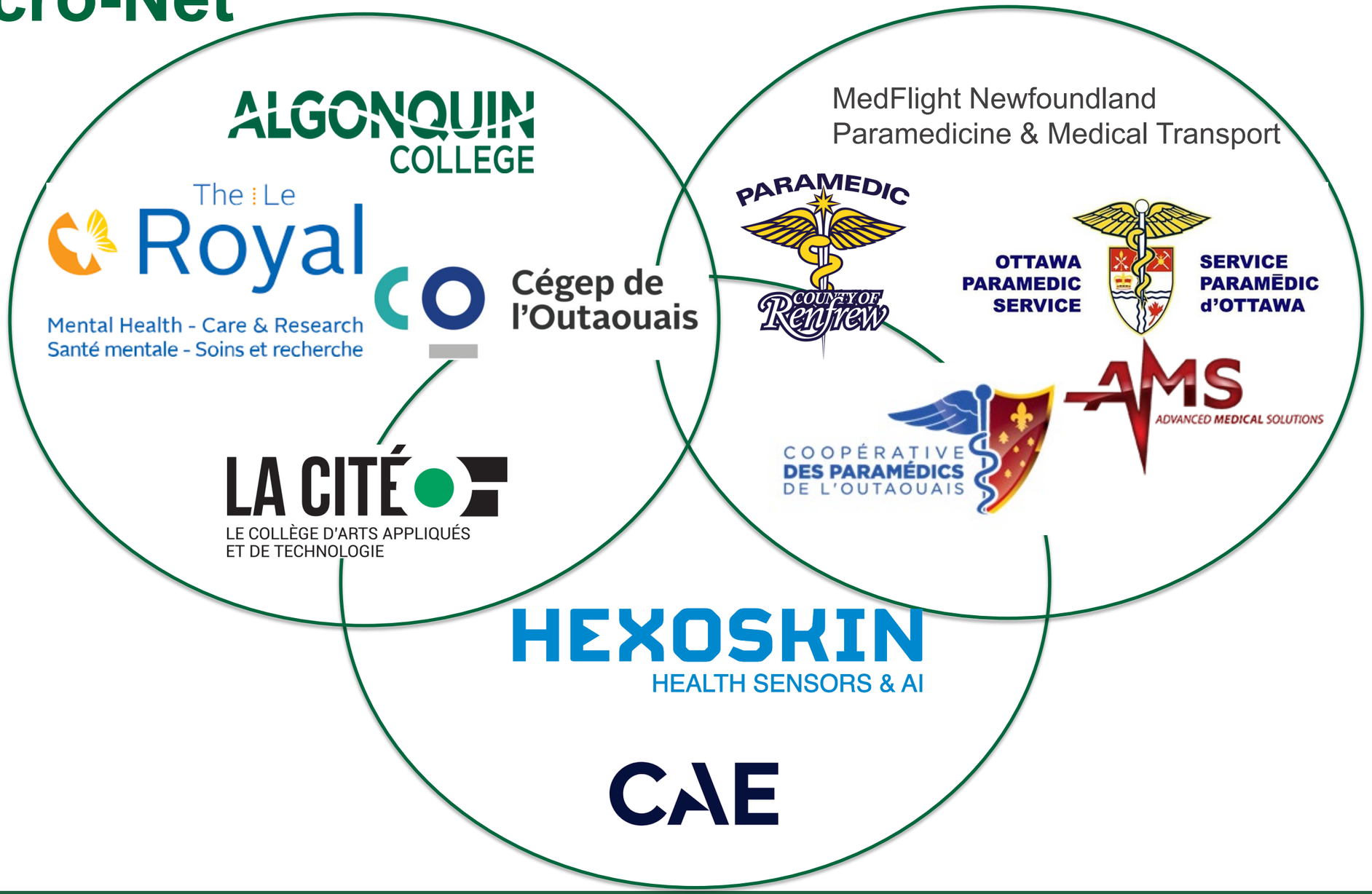
The Micro-Net



Research Rationale

- A recent national survey of PSP found that **1 in 4 participating paramedics screened positive for PTSD, 1 in 3 for major depressive disorder, and 1 in 3 for an anxiety disorder** (Mausz et al., 2022).

- In Canada, Carleton et al. (2018) have shown that **paramedics reported statistically significantly higher prevalence of lifetime suicidality compared to other PSP**. It has been suggested that current paramedics, and those training for the field as students, would benefit from more formal training on resiliency due to the stress of the job (Vaughan et al., 2020).

Why are we doing this work?

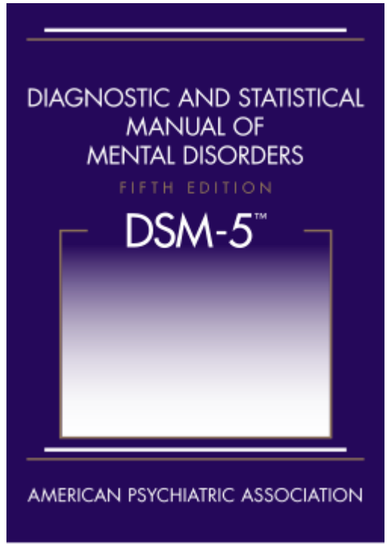
The percentage of paramedics who reach retirement age varies, but research indicates it's **relatively low**. Studies suggest that a significant portion of paramedics, often around 75%, experience burnout and leave the profession before reaching retirement.

In some regions, like Ontario, paramedics over 55 years old only represent about **4% of the total workforce**. This is often attributed to the **physical and mental demands of the job, which can lead to early retirement or leaving the field altogether.**

Operational Stress Injury

Prevalence of OSI among paramedics
(self-report measures)

Type of OSI	Canadian Paramedics (Carleton et al., 2018)	Ambulance Personnel Worldwide (Petrie et al., 2018)
General psychological distress	-	27%
Anxiety	20.5%	15%
Depression	29.6%	15%
PTSD	24.5%	11%
Alcohol use disorder	6.1%	-
Panic disorder	10.3%	-
At least 1 mental disorder	**49.1%**	-



Dispatchers

“As a 9-1-1 Dispatcher, we are rarely, if ever thought of or considered as first responders, even though we are the very first people contacted when someone is having a crisis. Anyone with a significant amount of time served in this job can tell you stories about hearing suicides take place, physical assaults in progress, verbal abuse from citizens that you are required to help, and all sorts of heinous acts that stick with you for a very long time.”

(O'Dare et al., 2023)

https://digitalcommons.unf.edu/cgi/viewcontent.cgi?article=1292&context=fphr

Algonquin College Project Team

Diana McGlinchey, Msc.
Principal Investigator,
Victimology Research Centre

Ashley Murfin, MHSM
Professor / Coordinator,
Paramedic Program

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Bachelor of Public Safety

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Victimology Research Centre

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Deputy Chief (Retired),
Renfrew Paramedic Services

Ravichandra Rachamalla
Research Associate,
Digital Technology Centre

Dr. Maria Ghosn-Chelala
Professor,
Bachelor of Public Safety

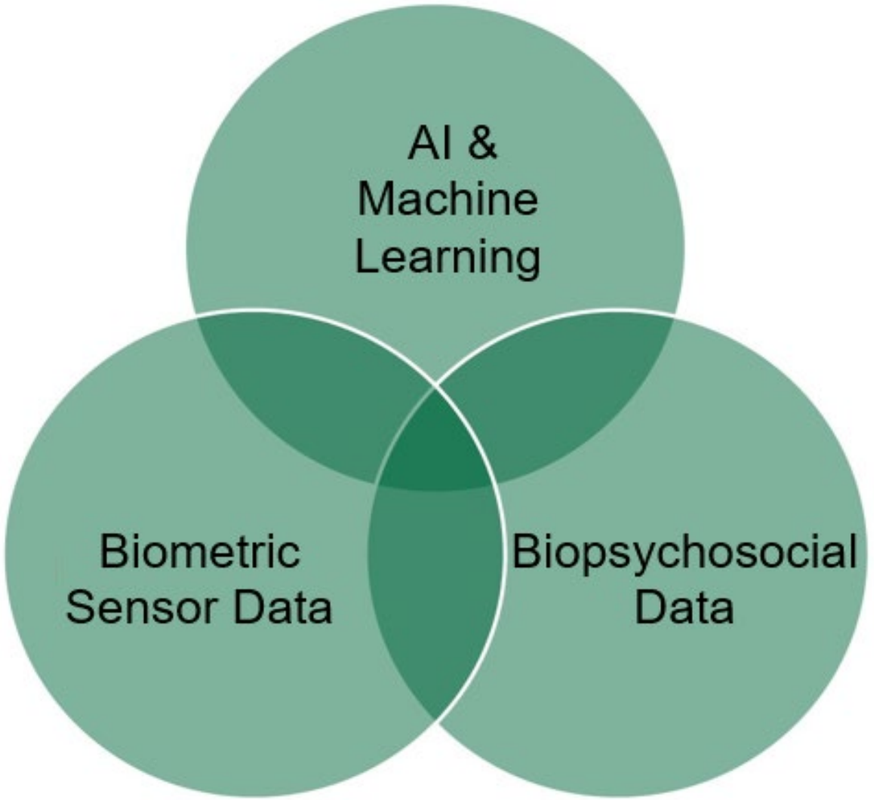
Research Assistants:

Matthew Cosgrove
Will Daniel
Ciaran Snowdon
Brayden Warrell

Coop Students,
Bachelor of Public Safety

Research Question

Adopting a biopsychosocial lens, this research has been designed to assess to what extent can quantitative biometric data gathered through wearable technologies—combined with qualitative measures of social and psychological wellbeing gathered through self-reporting surveys, validated scales, and semi-structured interviews—support the development of machine learning AI models to identify stress responses among first responders.



HEXOSKIN
CONNECTED HEALTH PLATFORM

ASTROSKIN
VITAL SIGNS MONITORING PLATFORM

HEXOSKIN METRICS
1-Lead ECG

- 1-Lead ECG
- Heart Rate Recovery
- Heart Rate Variability
- Breathing Rate
- VO2 max
- Minute Ventilation
- Acceleration
- Calories
- Cadence
- Activity Level
- Step Count

ASTROSKIN ADDITIONAL METRICS
3-Lead ECG

- Blood Pressure
- Skin Temperature
- O_2 Blood Oxygen Levels

HEXOSKIN BATTERY

Hexoskin **Classic**
12H+
Of Battery Life
USB Rechargeable

Hexoskin **Smart**
30H+
Of Battery Life
USB Rechargeable

ASTROSKIN BATTERY

Astroskin **Device**
48H+
Of Battery Life
2 Replaceable AA Batteries

Being Used on International Space Station

https://hexoskin.com/

The Sensors

CARDIAC SENSORS

- ECG (1 channel, 256Hz)
- Heart Rate: 30-220 BPM, 1Hz
- QRS event detection: 4ms resolution
- RR intervals: 4ms resolution
- HRV analysis
- Quality assessment channels:
  - Disconnection detection
  - 50-60Hz noise detection
  - Saturated ECG signal detection
  - Movement artifact detection
  - RRintervals reliability detection

https://hexoskin.com/

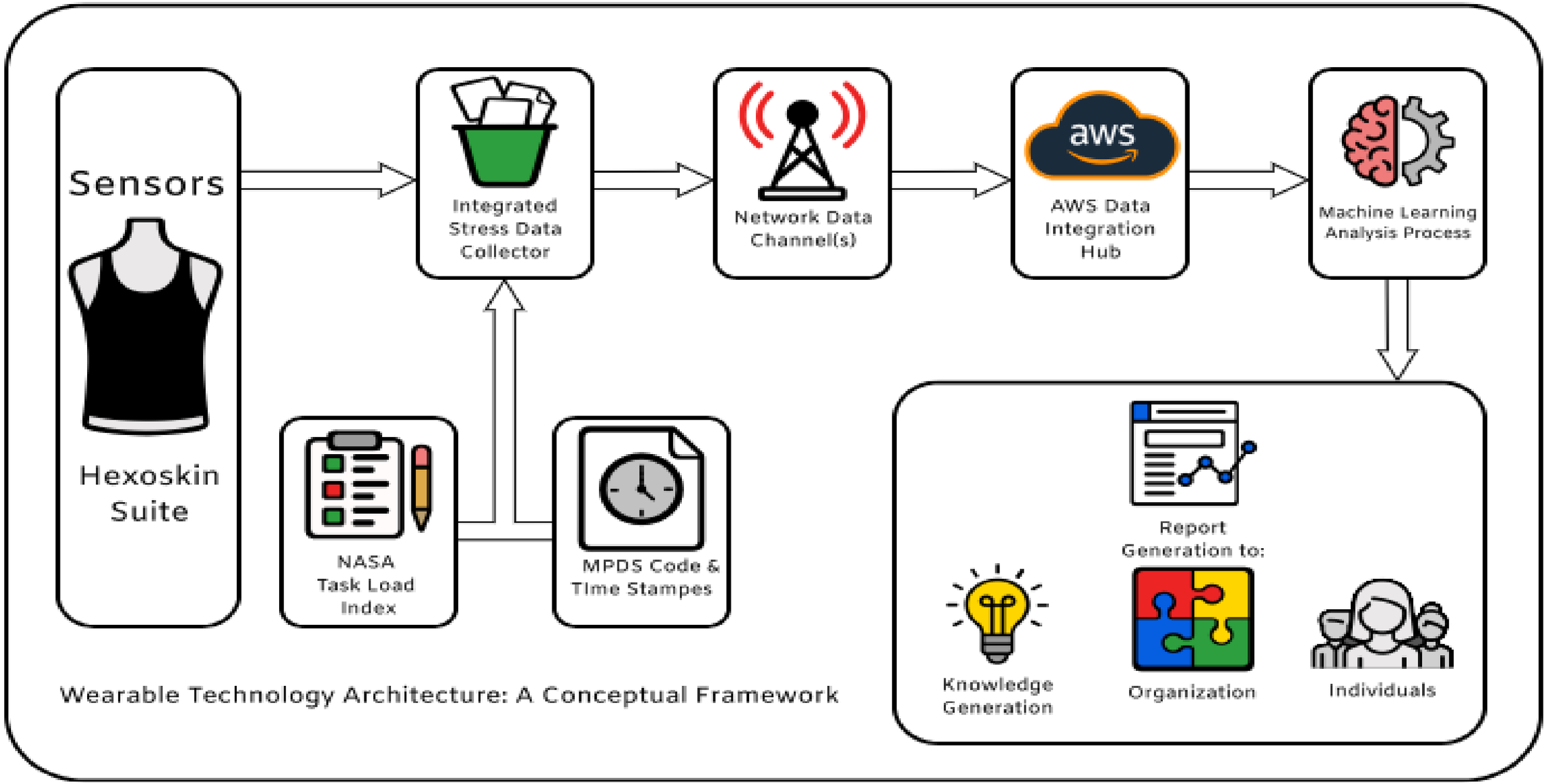
The Sensors

BREATHING SENSORS

- Breathing (2 channels, 128Hz)
- Breathing Rate: 3-80 BPM, 1Hz
- Tidal Volume (last inspiration), 80mL-10L, 1Hz
- Minute Ventilation, 2-150 L/min, 1Hz
- Inspiration and Expiration Events, 8ms resolution
- Quality assessment channels:
  - Disconnection detection
  - Noise detection
  - Baseline change detection

https://hexoskin.com/

Architecture



Machine Learning Pipeline: From Data to Prediction

1. Data Collection
   - Biometric Data (HRV, BR) from the Hexoskin Vests
2. Data Integration
   - Combine with NASA TLX scores and incident content
3. Preprocessing
   - Clean, normalize and segment time-series data
4. Feature Extraction
   - Derive biomarkers (HRV variable, BR trends)
5. Model Training
   - Train supervised and unsupervised models with the data
6. Evaluation and Prediction
   - Assess accuracy and generate stress forecasts

Project Benefits

1. **Technological Benefits:**
    1. Identification of new physiological markers for stress that can be modelled with AI
    2. Increase fidelity and accuracy of machine learning (80-85% to 90%)
2. **Operational Benefits:**
    1. Identification of time delay needed for first responder to come back to baseline after specific calls
    2. Reduction in days not work
    3. Employee turnover
3. **Socio-economic Benefits:**
    1. Measures identified that could assist in a reduction of trained paramedics no longer employed in the field
    2. Wait time for treatment
    3. Strain on health care systems

Methodology A

Step 1

Participant completes online survey with psychosocial measures of well-being.

Step 2

Participant wears HexoSkin garment for 2 months.

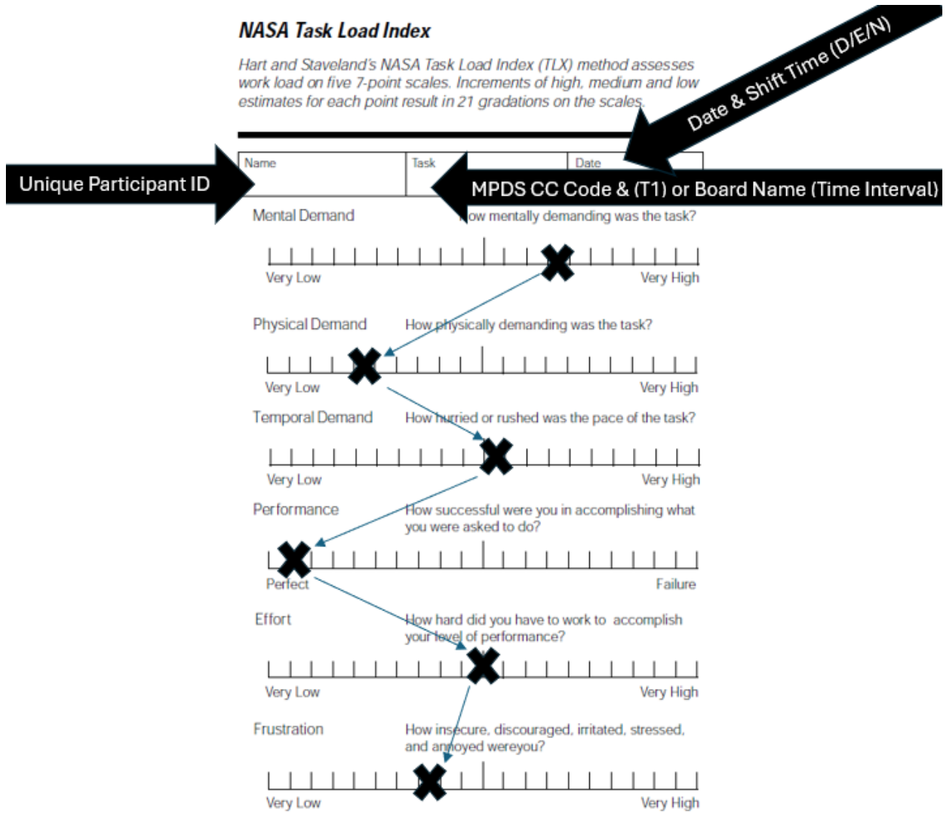
Participant completes NASA Task Load Index after each call (or at random intervals, in the case of dispatch)

Step 3

Participants self-select to participate in optional follow-up interviews

Medical Priority Dispatch System Emergency Medical Dispatchers

NASA Task Load Index



- How mentally demanding was the task ?
- How physically demanding was the task ?
- How hurried or rushed was the pace of the task ?
- How successful were you in accomplishing what you were asked to do ?
- How hard did you have to work to accomplish your level of performance ?
- How insecure, discouraged, irritated, stressed, or annoyed were you ?

MPDS Complaint CODES

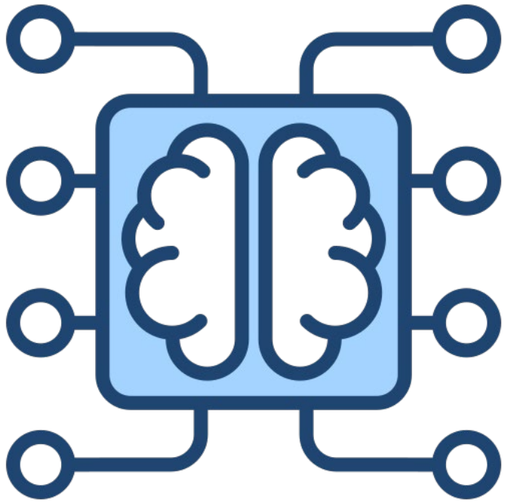
Code	Chief Complaint
1	Abdominal Pain
9	Cardiac or Respiratory Arrest
10	Chest Pain
23	Overdose
24	Pregnancy / Childbirth
28	Stroke
29	Traffic Collision

How this comes together…

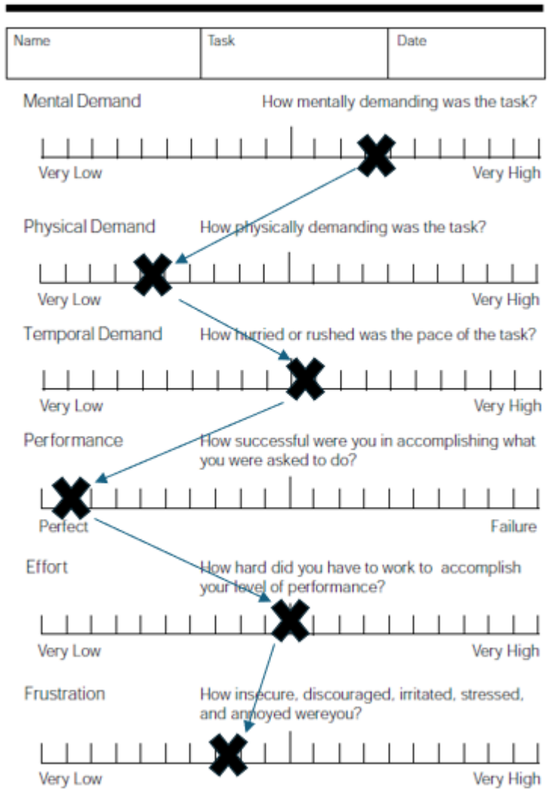
Physiological Data

HEXOSKIN
HEALTH SENSORS & AI

AI – Machine Learning



NASA TLX

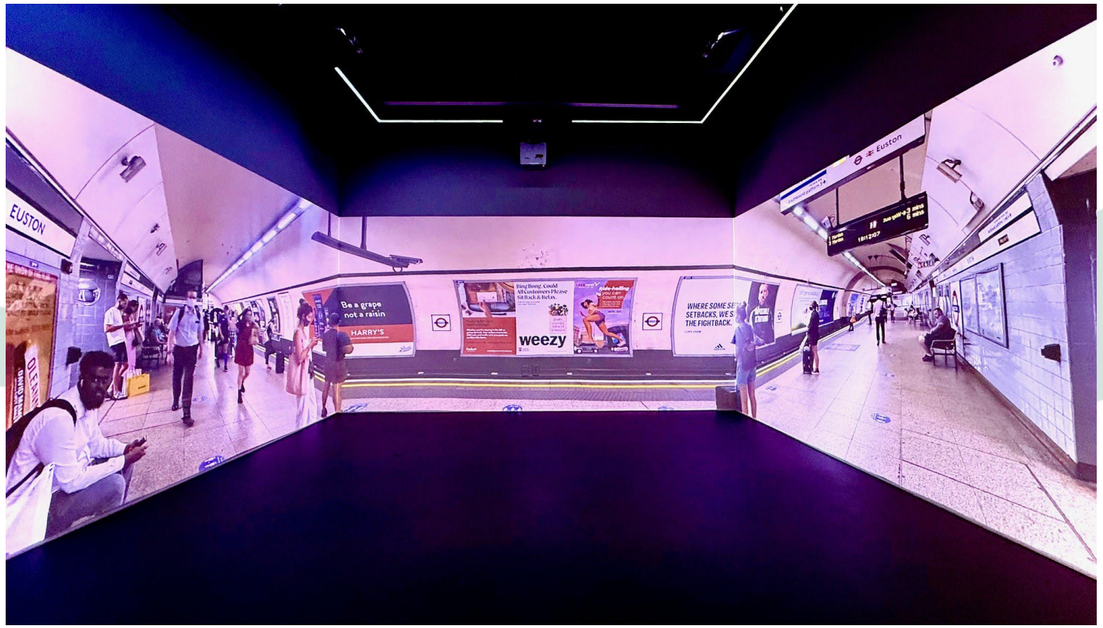


EMD: Harm Reduction Possibilities

- Which MPDS Codes are most impactful to the dispatcher?
- Time between calls that allow the dispatcher to return to physiological baseline before the next call
- Are staffing levels sufficient to match call demand and workload?
- Funding change data supported
- Workload breaks / pauses data supported

Allows the addition of distractions, lights, sounds, wind and smells, allowing the learner to interact with the dynamic and interactive simulation environment.

2025: New Immersive Lab



Methodology B

Control Group

Scenario 1

Scenario designed to provide a relative level of stress response to the profession/place in time of the participant (i.e. student or paramedic)

Scenario 2

Scenario designed to include same situation as 1 but with added external stressors

Test Group

Scenario 1

Scenario designed to provide a relative level of stress response to the profession/place in time of the participant (i.e. student or paramedic)

Intervention

Stress inoculation training

Scenario 2

Scenario designed to include same situation as 1 but with added external stressors

Four Studies

1. **Paramedic Students – Methodology B (Spring 2025)**
    - Pilot sample size: 6
    - Sample size: 6 per group

2. **Ottawa Paramedic Service Central Ambulance Communications Centre – Methodology A (Fall 2025)**
    - Sample size: 12-20

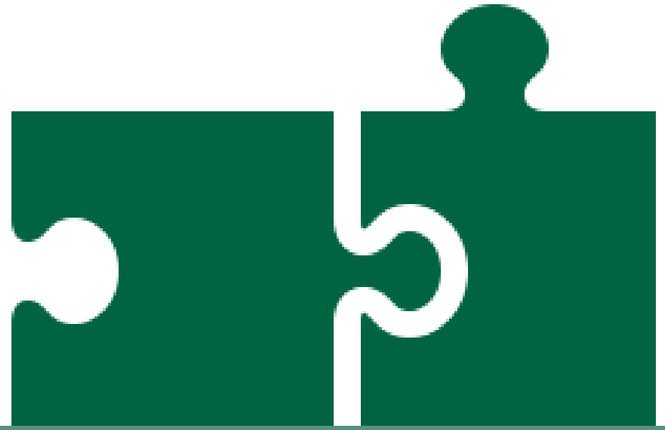
3. **Field studies (ex: Renfrew Paramedic Service, Gatineau Paramedic Service, Ottawa Paramedic Service) Methodology A (Spring 2026)**
    - Sample size: 30 per site

4. **MedFlight Newfoundland Paramedicine and Medical Transport – Methodology A and B (Winter 2027)**
    - Sample size: TBD

Project Timeline

Timeline	**Spring / Summer 2025**	**Fall 2025**	**Winter 2026**	**Spring / Summer 2026**	**Fall / Winter 2026 / 2027**	**Spring 2027**
Methodology	REB application for EMD	REB for field studies Protocol paper revisions	REB for flight paramedics			
Data collection	Paramedic students Experiment 1	EMD Experiment 2	Field studies Experiment 3	Field studies Experiment 3	Flight paramedics Experiment 4	
Data analysis		Paramedic students	EMD	Field studies	Field studies	Flight paramedics
Knowledge dissemination	Protocol paper / conferences	Conferences / lectures	Reports / peer reviewed papers / presentations / lectures	Reports / peer reviewed papers / presentations / lectures	Reports / peer reviewed papers / presentations / lectures	Reports / peer reviewed papers / presentations / lectures

Increasing Research Capacity & Engagement



Strong Support for Research

The School of Wellness, Public Safety and Community Studies is engaged in many research initiatives.

Leadership support is encouraging this work and allowing faculty time to dedicate to research projects.

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Applied Research

Paramedicine Research Centre

Current and Future Planning

Paramedicine (1967)

A unique specialty that links healthcare with emergency response. The evolution of paramedicine is happening within a vacuum without the supportive structures, associations, and supports to the level other public safety professions enjoy.

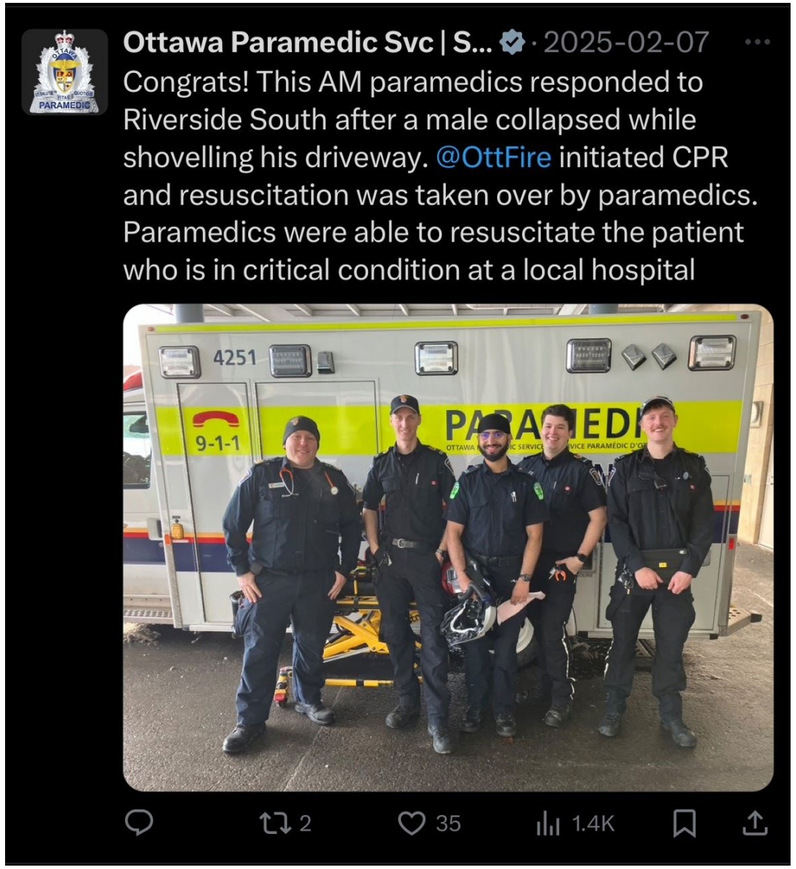
Eg: Military, police, fire and nursing

Paramedicine are the experts in mobile healthcare and bring healthcare to you.

Research data will drive the changes that can best help our communities.

Beginning their journey…

Involving the future leaders in research as early as possible.

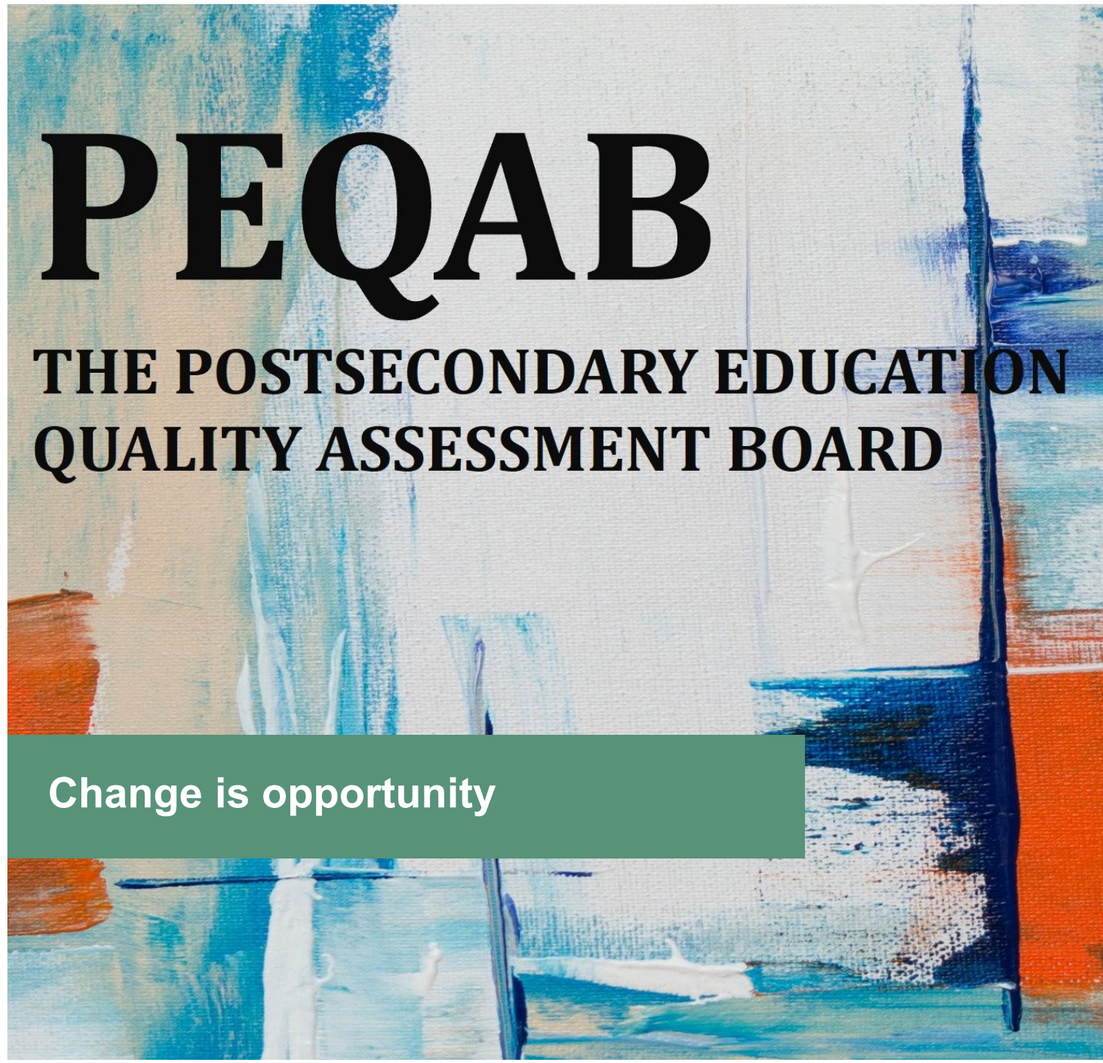


334 likes

ottawa_paramedic_service Congratulations to paramedics Jonathan and Chris as well as their student Dylan who assisted the delivery of a healthy baby boy over the weekend in Vanier. The baby was born inside the ambulance during the transport to the hospital! Congratulations to the family.

New 3yr. Bachelor Degree Scholarly Activities

- 3 Year Bachelor Degree in Paramedicine (Pending Approval)
- Possible start date: Fall 2026
- PEQAB: Requires faculty to engage in scholarly activities, which includes research



Paramedicine Research Centre Team Strengths

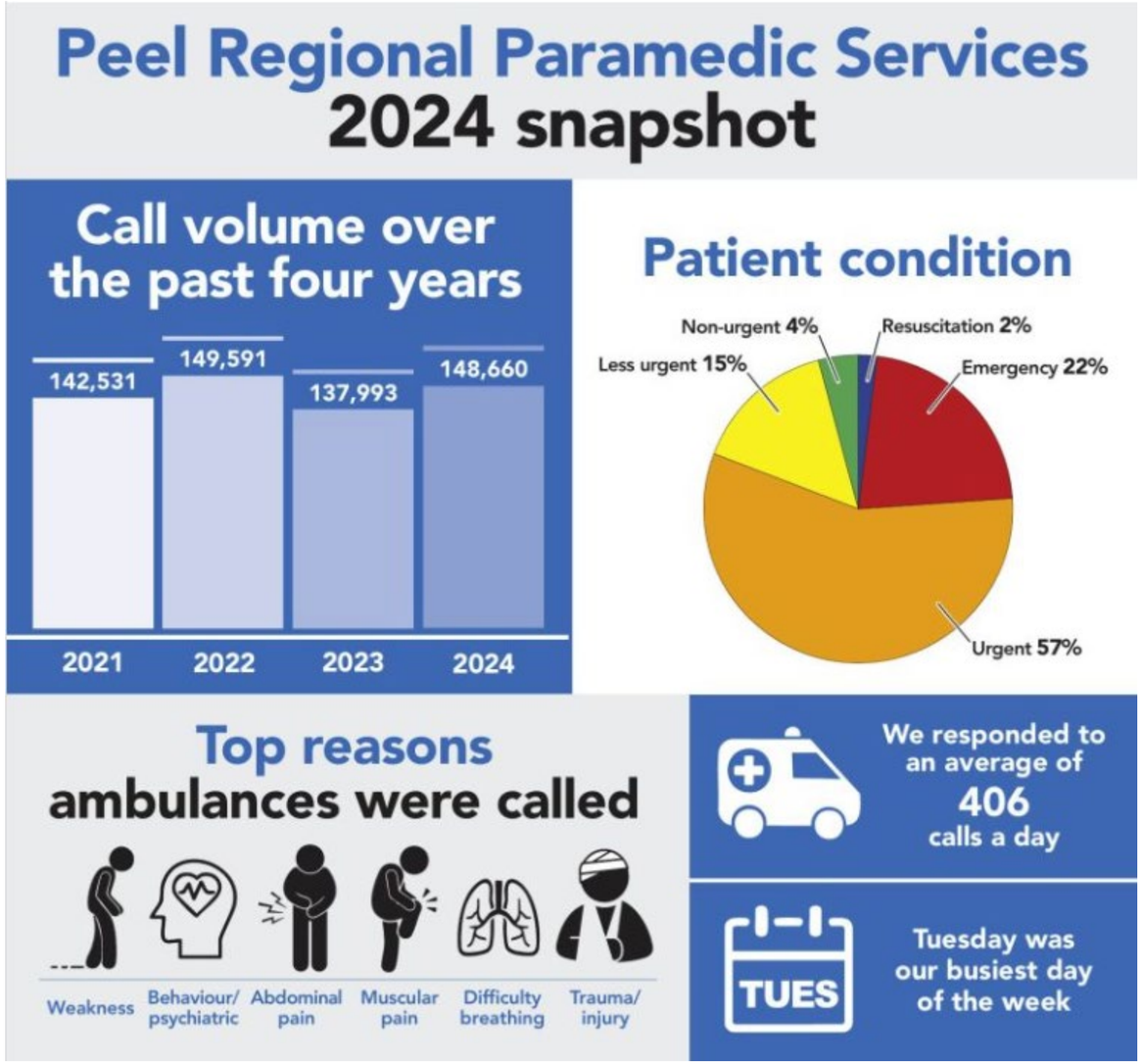
- Paramedicine industry knowledge
- Paramedicine industry relationships
- Psychosocial research experience
- Physiological research experience
- Grant writing expertise
- Keen learners wanting to engage

Solid Team Already Active

Paramedicine Evolution Currently In Progress....

Paramedic training needs to change with the expanding community needs

- More emphasis is needed on critical communication skills
- Complex medical needs of patients
- Social determinants of health
- Alternate care pathways



2024 CCSIF Awarded to Victimology Research Centre includes Partnership with Paramedic Research Centre

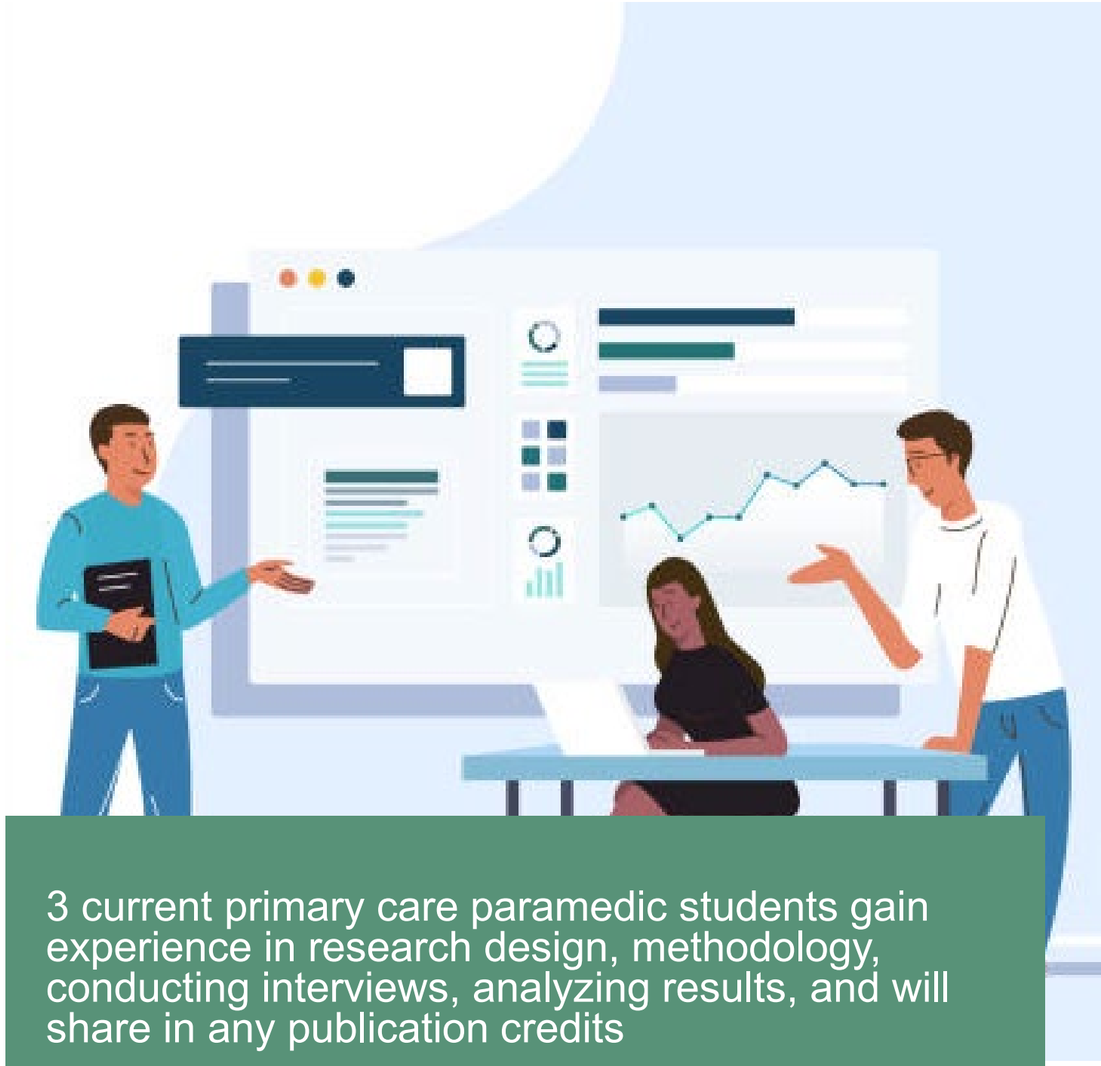
Often termed the ‘First’ First Responders, emergency medical dispatchers will be featured among other key professions in this national research agenda led by Algonquin researchers (Diana McGlinchey, P.I.) to better understand the impacts of trauma, mental health, and community supports for understudied populations of the “forgotten” first responders.

Mental Health and Well-being of Forgotten First Responders in Canada

Creating a Strong Research Culture through Research Assistantships

Testing Role Identity Dissonance Among Paramedic Students Undergoing Clinical Preceptorship: Pedagogical and Professional Reflections

Builds on emerging and topical literature by leading researchers within Canadian Paramedicine research, this research tries to understand the **importance of roles within healthcare** and **how to best train students** to have realistic expectations of the career to **improve outcomes and change pedagogy**



3 current primary care paramedic students gain experience in research design, methodology, conducting interviews, analyzing results, and will share in any publication credits

2025 CCSIF Applicants

Stethoscopes and Scissors: A Longitudinal Research Project Testing Role Identity Dissonance Among Paramedic Students and Professionals

- 3-year longitudinal project
- Responds to a call for research about training of paramedics to be more realistic, representative, and grounded
- Helping to better train paramedics and increase job satisfaction and readiness
- Eastwood et al. (2023) note that “in complex systems, roles become extremely important, and within healthcare teams, role clarity is directly linked to improved patient outcomes. At an individual level, role clarity is closely tied to stress and satisfaction.”

Community Partners

Expert Panel at the 2025 Canadian Sociological Association Conference as part of the National Congress of the Humanities and Social Sciences

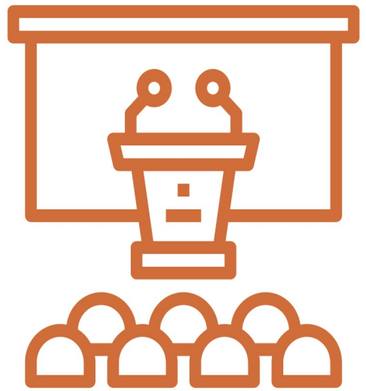
AC Panelists include:

- Ashley Murfin
- Dr. Chris Martin
- Diana McGlinchey

Collaborators:

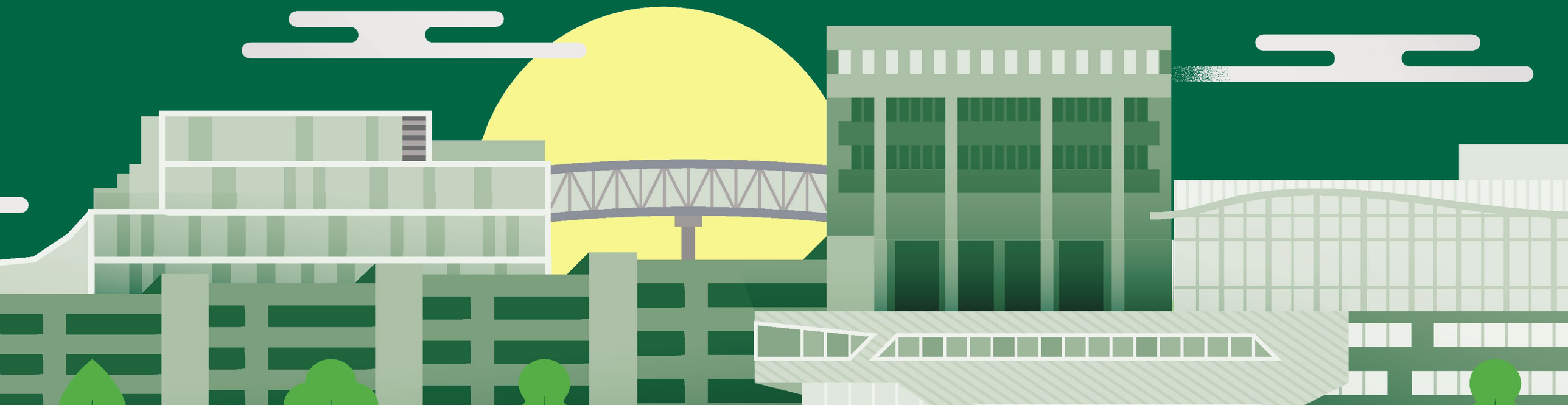
- Dr. Elizabeth Donnelly, Associate Professor in the School of Social Work at the University of Windsor.
- Dr. Michael Corman, Associate Professor in the School of Culture, Media, and Society at the University of the Fraser Valley.

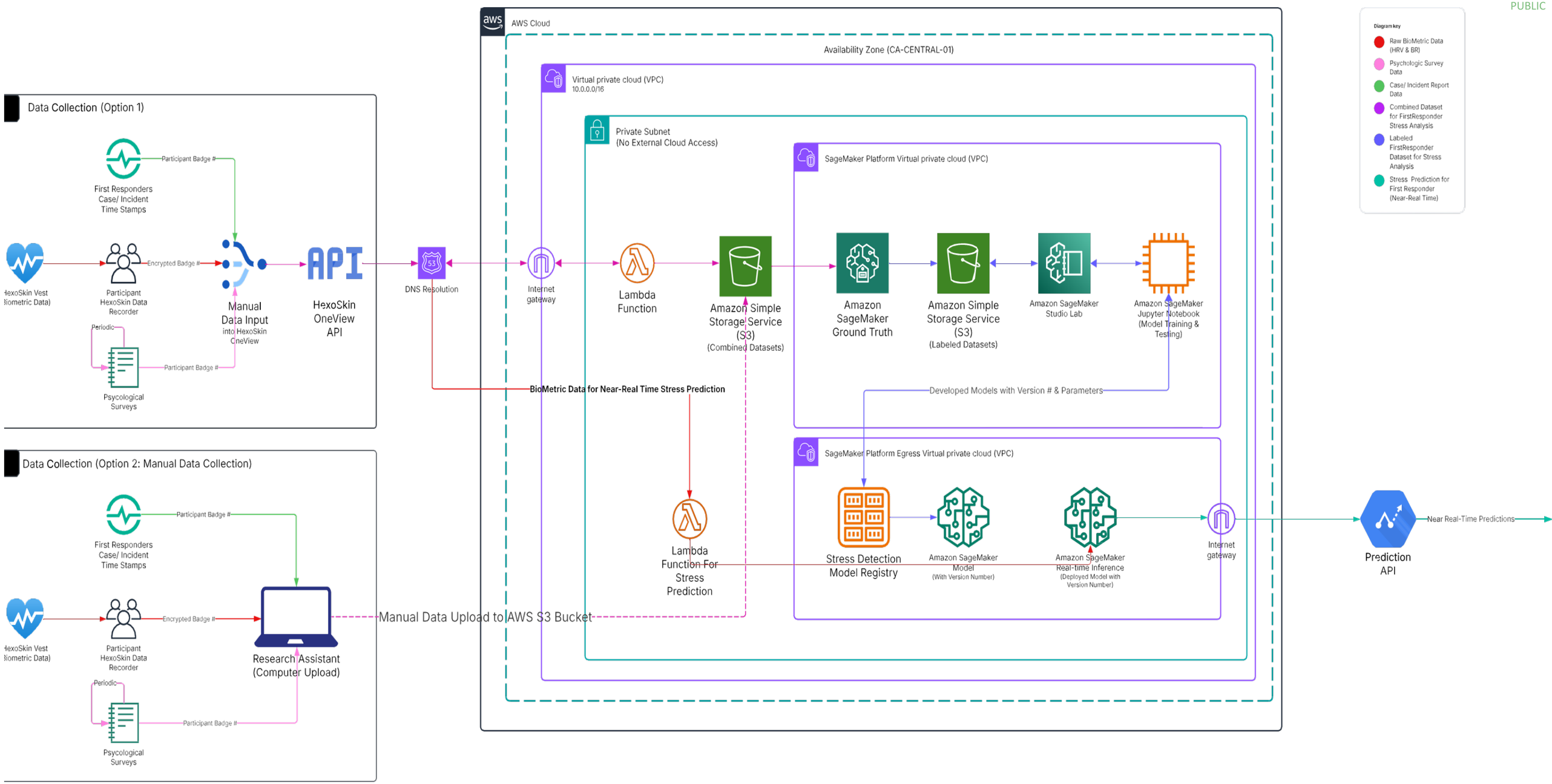
CSA Canadian Sociological Association Société canadienne de sociologie



Session title: The Sociology of (Forgotten) First Responders, Healthcare Workers, and Public Safety Personnel

Thank You!
Questions?




Data Collection (Option 1)
First Responders Case/ Incident Time Stamps
Participant Badge #
HexoSkin Vest (Biometric Data)
Participant HexoSkin Data Recorder
Encrypted Badge #
Manual Data Input into HexoSkin OneView
API
HexoSkin OneView API
Periodic
Psycological Surveys
Participant Badge #
Data Collection (Option 2: Manual Data Collection)
First Responders Case/ Incident Time Stamps
Participant Badge #
HexoSkin Vest (Biometric Data)
Participant HexoSkin Data Recorder
Encrypted Badge #
Research Assistant (Computer Upload)
Periodic
Psycological Surveys
Participant Badge #
Manual Data Upload to AWS S3 Bucket
DNS Resolution
aws
AWS Cloud
Availability Zone (CA-CENTRAL-01)
Virtual private cloud (VPC)
10.0.0.0/16
Private Subnet
(No External Cloud Access)
Internet gateway
Lambda Function
Amazon Simple Storage Service (S3)
(Combined Datasets)
SageMaker Platform Virtual private cloud (VPC)
Amazon SageMaker Ground Truth
Amazon Simple Storage Service (S3)
(Labeled Datasets)
Amazon SageMaker Studio Lab
Amazon SageMaker Jupyter Notebook (Model Training & Testing)
Developed Models with Version # & Parameters
BioMetric Data for Near-Real Time Stress Prediction
Lambda Function For Stress Prediction
SageMaker Platform Egress Virtual private cloud (VPC)
Stress Detection Model Registry
Amazon SageMaker Model
(With Version Number)
Amazon SageMaker Real-time Inference
(Deployed Model with Version Number)
Internet gateway
Prediction API
Near Real-Time Predictions
Diagram key
Raw BioMetric Data (HRV & BR)
Psychologic Survey Data
Case/ Incident Report Data
Combined Dataset for FirstResponder Stress Analysis
Labeled FirstResponder Dataset for Stress Analysis
Stress Prediction for First Responder (Near-Real Time)