Healthcare Analytics for Managing and Predicting Waits in Practice

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Data and Decision Sciences Team | Health System Performance and Support | Ontario Health
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Ontario Health (OH)

Who we are

- We are an agency created in 2019 by the Government of Ontario with a mandate to connect and coordinate our province's health care system to help ensure that Ontarians receive the best possible care.

What we do

- Coordinate the health system to help make it more efficient and to support patient-centred care.
- Oversee health care delivery across the province
- Provide evidence-based standards and improvements to address gaps
- Take a "digital first" approach to health care

Delivering Services Offered by Legacy Agencies

- Cancer Care Ontario
- eHelath Ontario
- Health Force Ontario
- Health Quality Ontario
- Health Shared Services Ontario
- Trillium Gift of Life Network
- Local Health Integration Networks

+

Digital Standards in Healthcare

Standards for virtual visit solutions, digital health information exchange, and online appointment booking.

Equity, Inclusion, Diversity and Anti-Racism

Our commitment to an equitable, anti-racist culture and health system

Mental Health and Addictions Centre of Excellence

Supporting Ontario in building a connected mental health and addictions system.

COVID-19 Resources

Materials shared with the Ontario health care system.

Community Care Resources and Support

Providing resources and training to help optimize patient care.

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Data and Decision Sciences Team

Advanced Analytics Competency for Health System Management

DDS team uses **descriptive, predictive, and prescriptive** analytics techniques to enable the organization to **design and deploy** robust health system initiatives, **predict** their intended and unintended outcomes, and **assess** their effectiveness.

Descriptive Analytics

(infer statistical insights from data)

Predictive Analytics

(predict patient/system outcomes)

Prescriptive Analytics

(recommend optimal course of action)

Methods Advisory

(confirm methods appropriateness and requirements)

Examples of Work with OH Partners

- Are COVID19 vaccines efficacious in CKD patients?
- Does following disease management pathways result in better outcomes?
- Does palliative care delivery differ among regions when adjusted for confounders?

- How will a new screening/diagnostic test impact downstream service capacity and wait times?
- How will a new home care initiative for persons living with Dementia impact the waitlist for LTCH facilities?

- How much capacity should be allocated to each region to minimize wait times for MRI?
- How many ICU beds are required to meet growing needs of the population?

- Optimization and simulation modelling
- Statistical modelling for prediction, risk adjustment, and inference
- Cost-benefit analysis & evaluation

Enablers

Data science & advanced analytics | Cross-sector data & modelling |stakeholder engagement and problem scoping | internal & external partnerships

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Wait Times Management

Ontario launched it's "Wait Times Strategy" in 2004

- Designed to **improve access** to healthcare services in the public system
- **Five areas**: cancer surgery, cardiac procedures, cataract surgery, hip and knee total joint replacements and MRI/CT
- Resulted in development of the **Wait Times Information System** (WTIS - housed in OH) and **public reporting** of wait times for surgeries, diagnostic imaging, and emergency departments (https://www.ontario.ca/page/wait-times-Ontario)
- Wait times for many other health services is monitored through other information systems and publications (e.g. radiation or systemic therapy wait times)

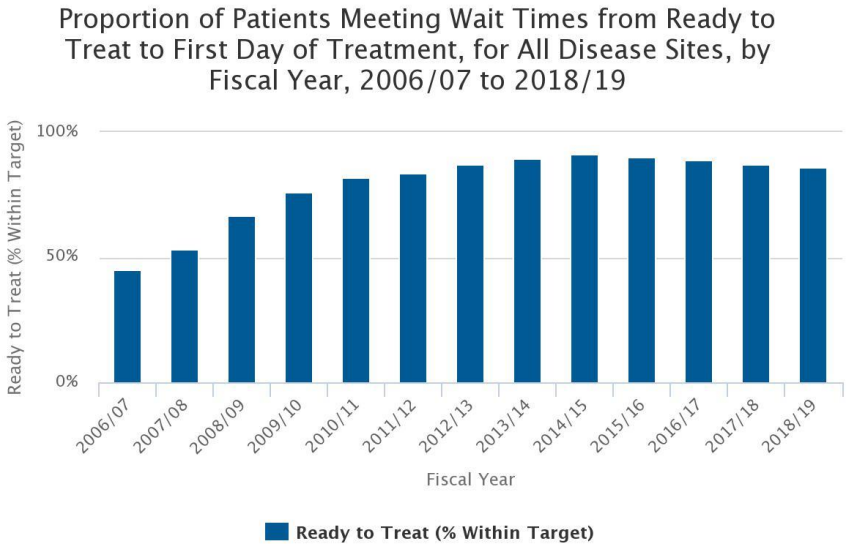
To manage wait times efficiently, we need to:

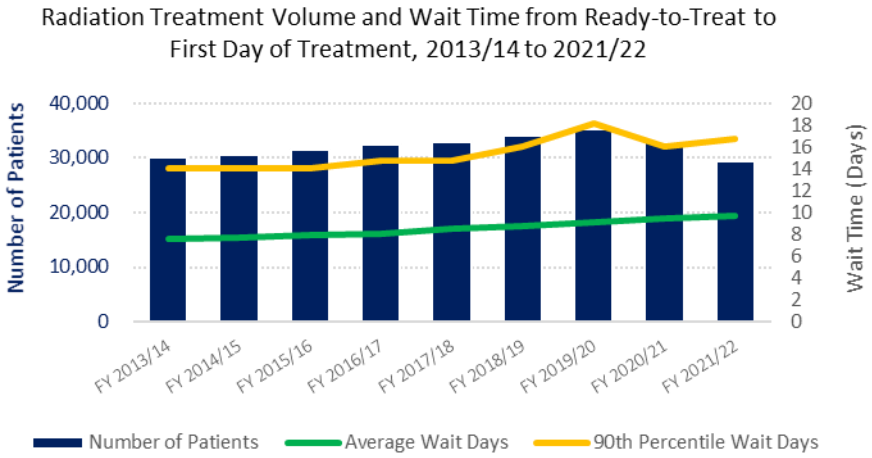
- Conduct **short-range** and **long-range planning** for **additional capacity**, aligned with growing population and demand for each service
- Focus on **improving process efficiency and appropriateness** to optimize the use of existing capacity

Planning for Radiation Therapy Capacity

- Radiation Therapy (RT) is a cancer treatment that uses high doses of radiation to kill cancer cells and shrink tumors
- In Ontario, RT investment strategies – developed by OH-CCO – have resulted in the number of RT machines doubling over the past 20 years and wait times improving significantly
- Increasing demand and wait times in recent years
- Current planning approach is based on expected patient demand and machine throughput with considerations for machine downtime*
- **Objective**: Recommend a "capacity buffer" – *in addition to expected demand* - to be considered when developing RT investment strategies and long range capital plans

*Radiation Treatment Capital Investment Strategy 2018, Cancer Care Ontario, https://www.cancercareontario.ca/en/programs/regional-cancer-programs/capital-investment-strategy)





Source: Activity Level Reporting (ALR), Cancer Care Ontario, 2022

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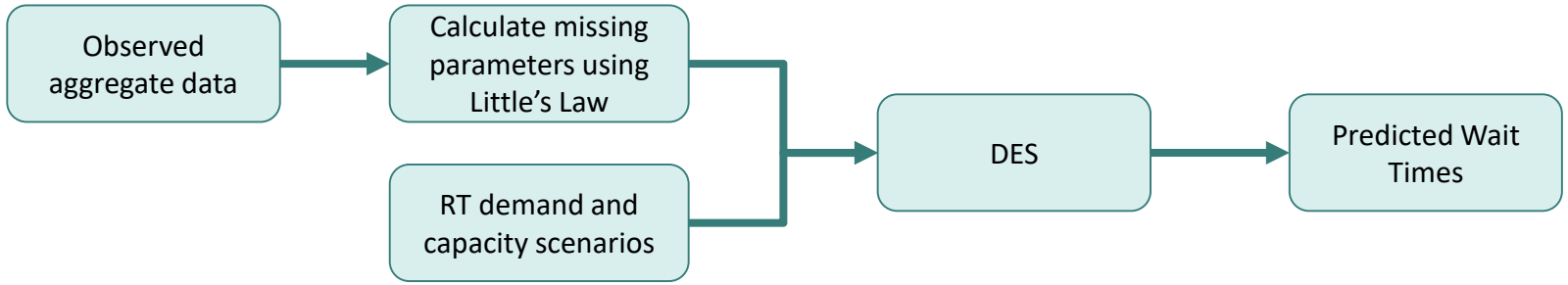
Overview of Data

- All cancer treatment activity in Ontario is recorded in Activity Level reporting (ALR) data source, housed at OH
- For this request we had access to aggregate data on treatment volumes and wait times for all cancer centres since FY2006/07
- **Challenge**: Patient level data as well as waitlist information was not readily available for this request

Overview of Approach

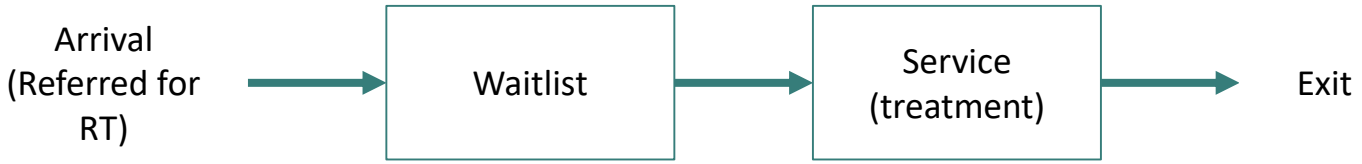


- Represent each facility as a single server queue and assume data reasonably meets stationary process assumptions (observed stable wait times)
- Use Little's Law to estimate arrivals and waitlist

$$W = \frac{1}{\mu - \lambda} - \frac{1}{\mu} \qquad L = \lambda W$$

W: Wait time in queue (days)
μ : throughput (number of patients starting treatment per day)
λ: arrival per day
L: Waitlist size (number of patients)

- Build a DES simulation model using arrival and service rate per day and starting queue



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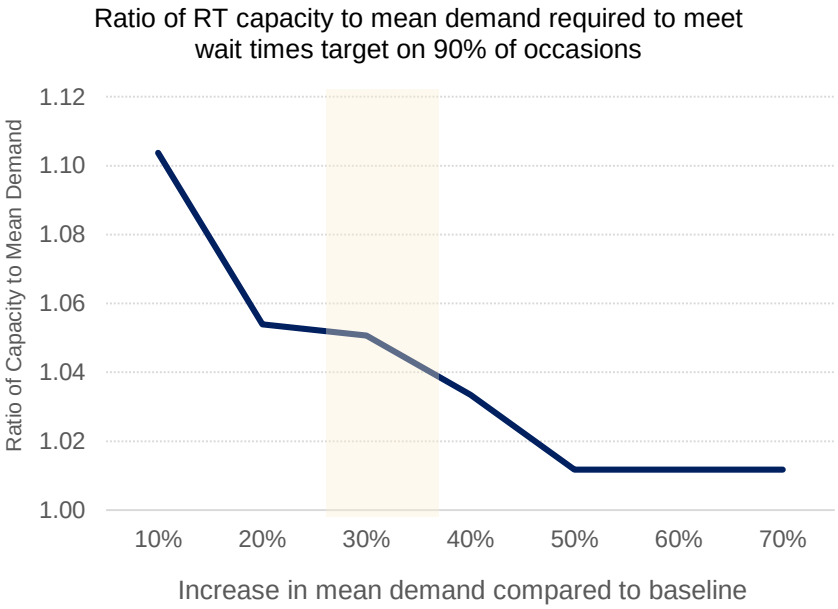
Preliminary Results & Next Steps

- A large sample facility (800 patients treated per qtr)
- A number of demand and capacity scenarios combinations were investigated to identify those where after 1 year, 90th percentile wait days are within 14 days
- As demand increases, the ratio of capacity to demand to meet wait time targets decreases
- For RT, with expected demand increase of >30% over the next decade, **a capacity buffer of 4-6%** may be appropriate to use in long range planning*
- Further validation required to ensure baseline scenario accurately captures current state and model performs well for other facilities



** Preliminary results; may change with further model modifications.*

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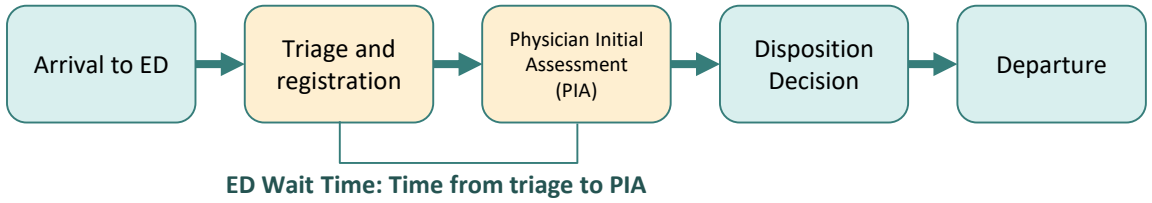
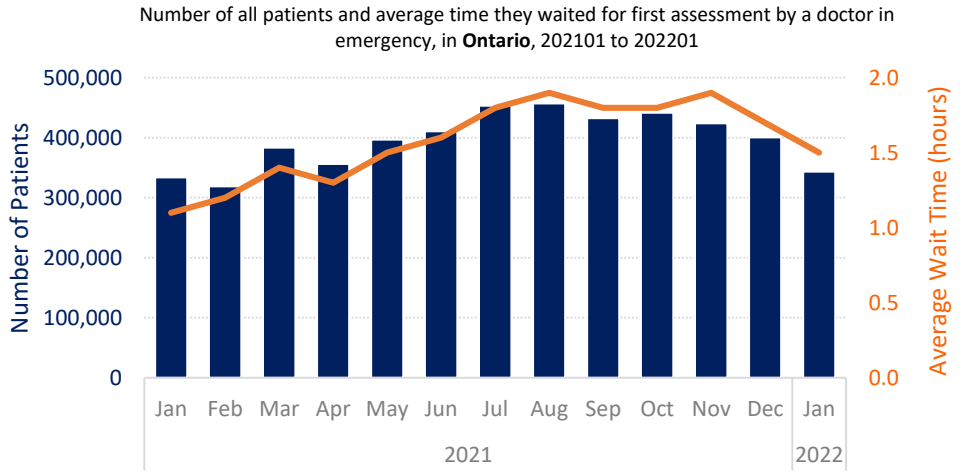
Predicting ED Wait Times

- ED wait times are defined as **time from triage to initial assessment by a physician**
- Financial incentives to reduce ED wait times in Ontario
- Live predictions of wait times published by some hospitals
  - Better **operational flexibility** and throughput of ED
  - Supporting clinicians in **prioritizing patients and adjusting workflow**
  - Improved patient satisfaction

- **Objective: Explore** feasibility & accuracy of wait times predictions, to:
  1. Provide live ED wait times predictions through one central system as opposed to multiple sources
  2. Predict changes to ED wait times as a result of a change in arrival patterns (e.g. if we expect ED arrivals to increase by 5% for a certain region/time period, how would ED wait times be impacted as a result)





Source: National Ambulatory Care Reporting System (NACRS), Canadian Institute for Health Information (CIHI) provided by Cancer Care Ontario (CCO) *from https://www.hqontario.ca/System-Performance/Time-Spent-in-Emergency-Departments*

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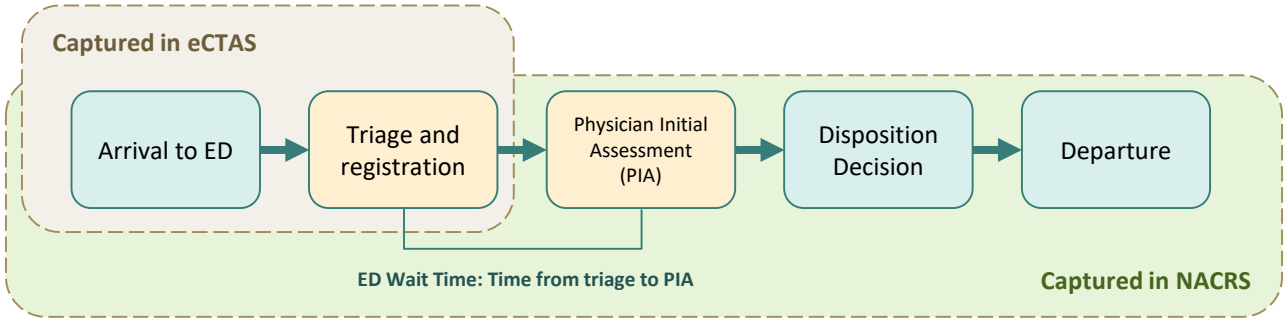
Overview of Data



Electronic Canadian Triage and Acuity Scale (eCTAS)

- An electronic triage **decision support tool** implemented in 2017
- Standardizes application of CTAS scores
- Improves patient safety and quality of care
- Provides a **live feed** of ED triage data in Ontario
  - Does not follow patients after triage
- Includes 126 hospitals currently, ranging from 4K to 133K annual ED visits

National Ambulatory Care Reporting System (NACRS)

- A data source for all hospital-based and community-based ambulatory care (Day surgery, Outpatient and community-based clinics and Emergency departments)
- Contains demographic, administrative, clinical and service-specific data for ambulatory care
  - Includes patient journey from arrival to departure, **including time to PIA**
- Has lagged data feed to OH with a monthly frequency

Both data sources required to link outcome of interest (ED wait time) with patient data at time of triage

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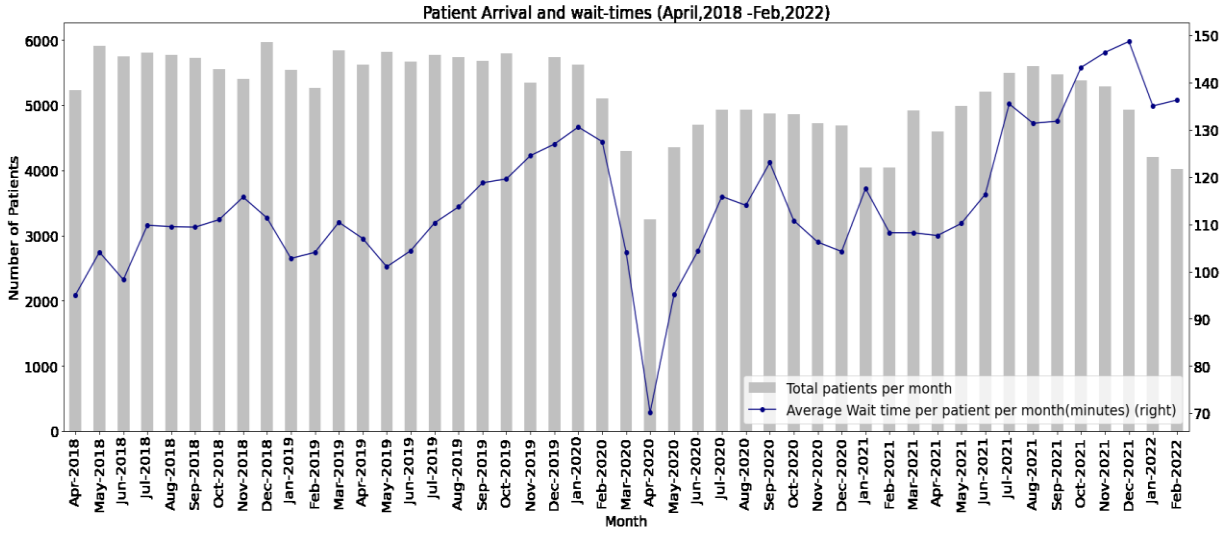
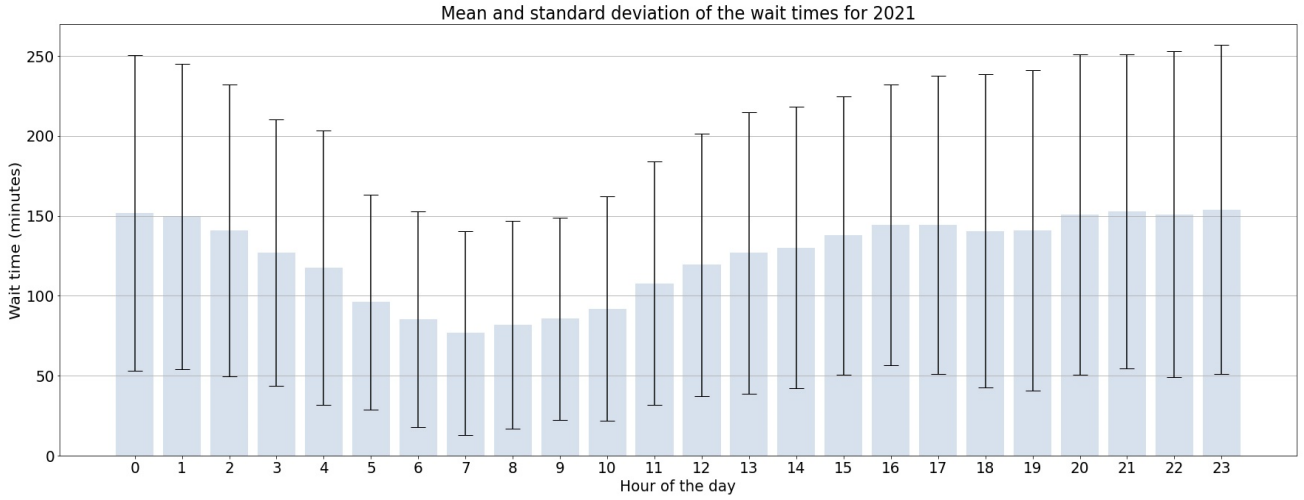
Sample Facility in Southwest Ontario

- A medium-sized facility with approximately 65K ED visits annually
- Selected for high data compliance and reliability of eCTAS tool implementation
- Wait time trend shows the disruption of the pandemic and increasing wait times
- Wide distribution of wait times within each hour of day – prediction accuracy may be impacted as a result





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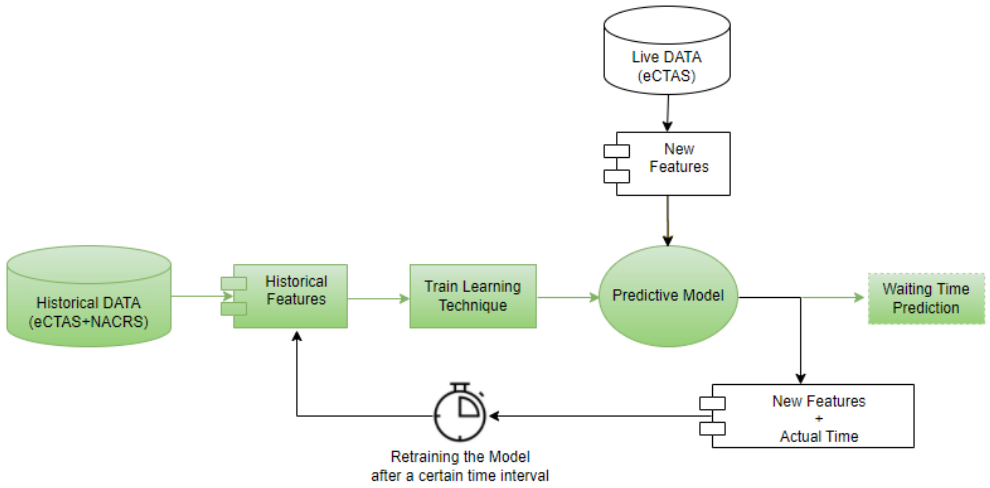
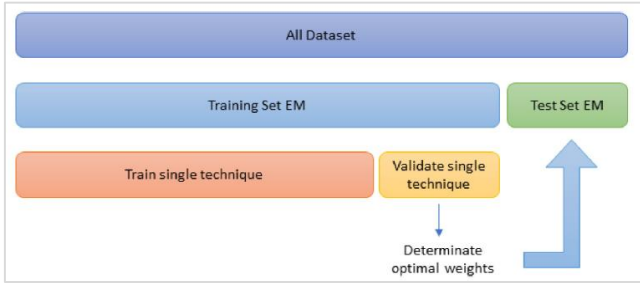
Overview of Approach

- Design a real-time wait time prediction system
- Derive features based on literature and data feasibility as
  - **Patient features –** *e.g. age, presenting complaints, CTAS score*
  - **Temporal features -** *e.g. Day of the week, Hour of the day, Day of the year*
  - **Arrival based features** - *e.g. number of arrivals in the past hour* (in progress)
  - **Queue based features** - *not available in the live data*
- Employ Ensemble Method (EM) as our prediction model
- Assess accuracy of each learning technique using mean squared error (MSE) and mean absolute error (MAE), Symmetric Mean Absolute Percent Error (sMAPE)

Real-time Prediction System



Ensemble Method Model Development Cycle



Source: Elisabetta Benevento, Davide Aloini, Nunzia Squicciarini (2021) *Towards a real-time prediction of waiting times in emergency departments: A comparative analysis of machine learning techniques.* International Journal of Forecasting. https://doi.org/10.1016/j.ijforecast.2021.10.006

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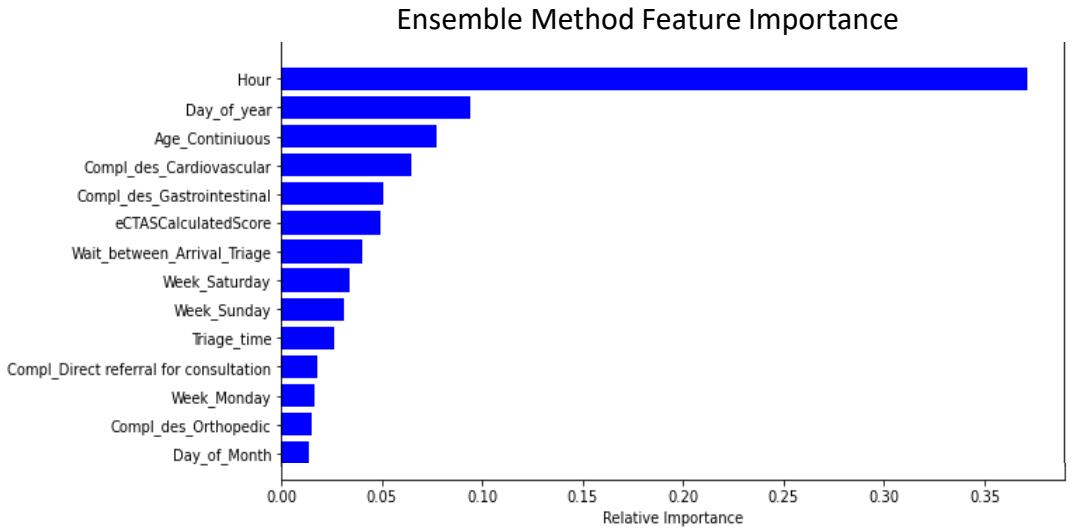
Preliminary Results and Next Steps

- Performance of our EM implementation is low with existing features
  - MAE: 69 mins
  - RMSE: 90 mins
  - sMAPE: 28%
- Important features for prediction:
  - Age , eCTAS score, Cardiovascular and GI complaints
  - Hour of the day, Day of the year, Weekends
  - Waiting time between arrival and triage
- **Next Steps**
  - Investigating **additional algorithms** for performance comparisons
  - Including data from **other facilities**
  - Including **additional features** including additional arrival features



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Final Thoughts

- Managing waits in an ongoing challenge in a public healthcare system
- Ontario Health and the province approach this challenge from multiple angles by planning and advocating for **more capacity**, investing in and **supporting providers** with innovative solutions to improve process efficiencies, including use of predictive and prescriptive models
- Simplifying assumption and iterative approaches to model development continues to help in showing the promise of analytics and results in stakeholders buy-in

Thank you!

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