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Med-Direct: Your AI Powered Decision support system

An AI powered decision support system for William Osler Health System. Utilizes medical directives to streamline ER processes, reduce wait times and overcrowding, and improve patient satisfaction.

Spec Status: Draft / Peer Review / Mentor Review / **Complete**

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Last Updated: 14-02-2025
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Summary

Your AI powered automated decision support system aims to reduce wait time in ER's by optimizing the use of medical directives. Available on williamoslerhs.ca. Med-Direct allows Authorized personnels (nurses) to enter patient complaints, vital signs, medical history and allergies and it makes preliminary decisions about whether they meet the criteria for the medical directive. This preliminary decision appears as a suggestion to the nurse who will either confirm the decision or override it. When medical directives are used in an optimal manner, ER processes become more streamline which reduces the amount of time wasted on waiting for test results.

Overview

Problem Statement / Motivation

From the initial user research, it was observed that most patients who made use of the William Osler Health System do not make use of the website at home. The main cause of patient dissatisfaction was long wait-times in the ER, which were observed to be a symptom of a larger issue within the department. Most interviewees acknowledged the lack of medical physicians and nurses to be the main cause of lengthy wait times which aligns with the finding of the office of the Auditor general of Ontario. The publication from the office of the auditor general in Dec 2023 also mentioned lack of beds, along with delays in lab tests and imaging, are part of the major causes of long wait times.

Problem statement: How can we increase patient satisfaction, reduce overcrowding and long wait times at William Osler Health System Emergency departments.

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Goals & Non-Goals

Goals

- To reduce wait time of patients. (Using AI)
- To streamline ER work flow and processes with the goal of improving patient satisfaction level and drive revenue. (Using AI)
- To reduce administrative tasks and paperwork, reallocating effort to patient care and helping to reduce overcrowding.
- To obtain digital data to easily measure impacts of process improvement activities.

Non-Goals

- Provide real time dynamic wait time to patients on website
- Mitigate Communication issues due to language barrier.
- To Transcribe findings automatically to allow ER Physician to focus more on patients care, especially during peaks hours
- To ensure consistent and accurate assignment of acuity levels during triage process

User stories / use cases

Persona	User Story and job to be done
ER Patient	Looking to spend the least possible time at ER so I can get home to my family
ER Nurse	To reduce wait time of patients to help manage inflow during peak hours.
	To reduce administrative tasks/paper work to reallocate effort to patient care and reduce overcrowding.
ER Doctor	To streamline ER work flow process and reduce wait time especially during peak hours.
	To generate more income while providing high quality health care.
Hospital Executives	To obtain digital data to easily measure impacts of process improvement activities.
	To streamline ER processes with the goal of improving patient satisfaction and drive revenue.

Customers and Business Impact

Customer Impact

For hospital patients, this solution could greatly reduce the time spent in the emergency room, leading to less frustration and higher patient satisfaction. This would also increase the safety and quality of healthcare, as it increases the likelihood of patients receiving timely treatment.

Business Impact

For of William Osler Health System administration, Physicians and nurses, this solution will give them as opportunity to:

1. Obtain digital data to enable them track Impact of medical directives on wait time.
2. Managing of work flow efficiently
3. **Streamlined documentation and communication**: Medi-Direct electronically documents labs, medications and any other required details for the medical directive, reducing administrative/ paper work. Nurses can redirect this time to other useful activities.
4. **Reduced Wait Times**
5. Improve consistency, ease and speed of decision-making during nurse assessment
6. **Training for Staff:** With automated decision support, Med-Direct can help train new staff members and ensure they follow best practices in using medical directive during initial nurse assessment.
7. **Operational Cost Reduction:** By reducing inefficiencies, minimizing errors, and improving resource allocation, Med-Direct can contribute to lowering operational costs in the ER.
8. **Avoidance of Redundant Tests/Procedures:** Through streamlined processes and access to patient data, unnecessary tests and procedures can be minimized, improving cost-effectiveness.

Solutions

To assess potential solutions, we must first understand the causes of long wait times and overcrowding in the ER. The primary causes identified were shortage of ER physicians and nurses, lack of available beds, and delays in lab tests and imaging.

Figure 1 illustrates patient flow within the ER.

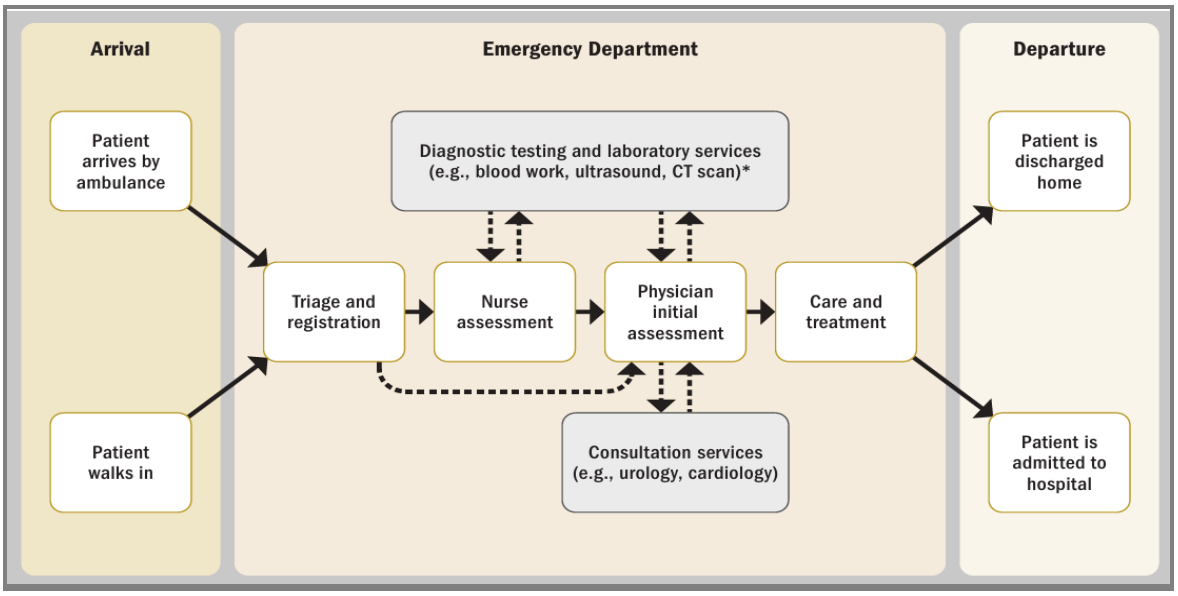


Figure 1: Work flow in ED

We will be addressing this problem from 2 perspectives:

- Root Cause
- Process Optimization

Addressing the root causes of physician, nurse, and bed shortages is outside the scope of AI product management. However, we can explore reducing the volume of tasks performed by these ER professionals, allowing them to focus on patient care.

Therefore, we have two potential solutions for addressing the identified root causes:
- Reducing the time spent on documentation and administrative duties for doctors and nurses using an AI-based transcription feature.
- Addressing delays in labs and imaging.

From a process optimization standpoint, we have three potential solutions:

- Streamlining the triage process.
- Utilizing medical directives during the nurse assessment stage to reduce delays in labs and imaging.
- Providing ER patients with dynamic wait times, enabling them to choose which ER to visit based on both wait time and proximity. This approach aims to redirect traffic to ERs with the shortest wait times within a defined proximity.

One of the solutions identified under process optimization overlaps with a root cause solution, resulting in four distinct potential solutions:

1. Providing ER patients with dynamic wait times to help them decide which ER to visit based on both wait time and proximity.
2. Streamlining the triage process.
3. Reducing the time spent on documentation and administrative duties for doctors and nurses using an AI-based transcription feature.
4. Utilizing medical directives during the nurse assessment stage to reduce delays in labs and imaging.

Let's have a detailed look at the 4 possible solutions in depth.

Alternative solutions

1. Providing ER patients with dynamic wait times to enable them decide which ER to visit considering both wait time and proximity.

This approach attempts to redirect traffic to ER's with least wait time within a defined proximity.

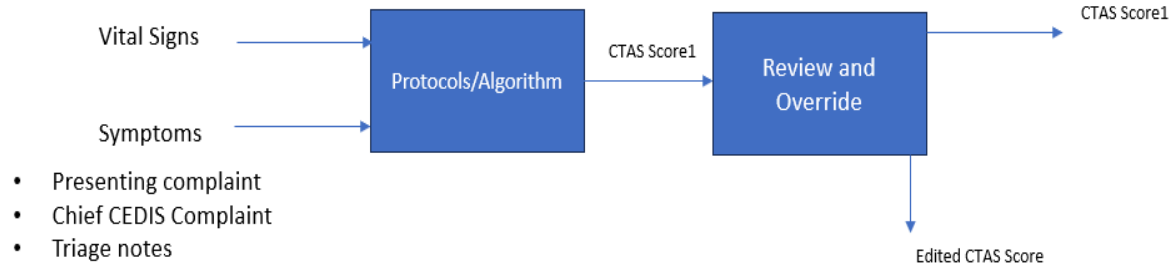
Drawbacks

From the user interview findings, it was observed that most ER patients do to utilize the hospital website. Therefore, simply publishing dynamic wait times on the website may not be effective without some form of promotion or outreach.

Secondly, remotely directing ER traffic to a different hospital before triage may not be effective or entirely safe, as a patient's condition could quickly change due to unforeseen complications. Therefore, we will not pursue this solution.

2. Streamlining the triage process

The William Osler Health System is currently making use of the electronic Canadian triage acuity system to assign acuity level of patient who visit the ER.



Presenting complaint refers to the patient's primary reason for seeking medical attention, while a chief CEDIS complaint is the most relevant complaint from a standardized list (Canadian Emergency Department Information System) used to categorize the presenting complaint and determine the appropriate acuity level based on established guidelines; essentially, the CEDIS complaint is a more specific way of classifying the patient's main concern using a standardized terminology.

Figure 2 gives as us a web view of the eCTAS system.

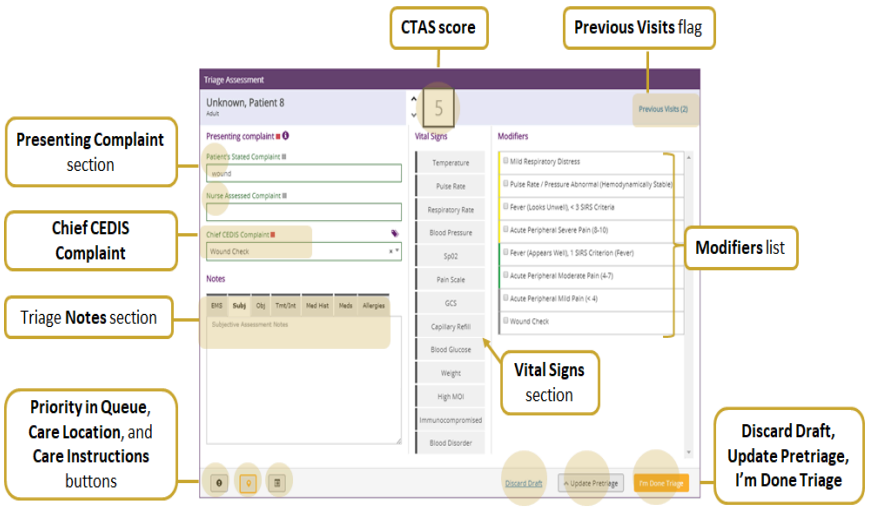
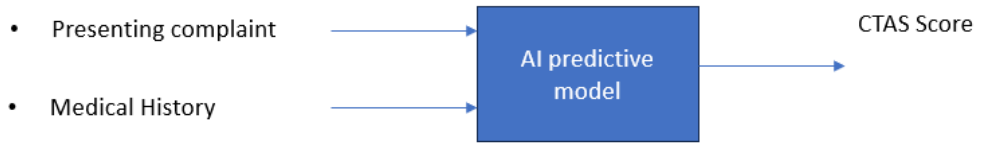


Figure 2: eCTAS web view

Drawbacks of eCTAS:

Does not account for dangerous complaint combination, depend on nurse to make these connections
eCTAS Not feasible for remote setting due to need for vitals and nurse assessment
-Highly dependent on nurse's assessment/input (nurse assessment + stored protocols to improve speed of triage)

The Drawbacks of eCTAS can be addressed with an AI enhanced triage system.



AI could be used to evaluate presenting complaints and predict eCTAS scores, potentially addressing dangerous complaint combinations or possible biases in triage. This could also enable self-service triage stations in the ED, freeing up triage nurses to focus on patient assessment and thus reducing wait times.

If AI enhanced triage system is able to predict accurate and consistent acuity scores without the need for vital signals and the dependence on triage nurses, It would present the possibility of remote. This makes it possible to safely direct patients to the right facility while they are home. However, due to complexity of implementation, we will not be making use of this solution.

3. Implementing an AI transcription feature

Implementing an AI transcription feature in an ER environment presents challenges due to background noise, increasing the complexity of implementation. Furthermore, the potential impact of an ER auto-transcription feature is less significant compared to the selected solution.

4. Proposed Solution

Med-Direct: Your AI powered medical directive

An AI-driven automated decision support system for William Osler Health System utilizes medical directives to streamline ER processes, reduce wait times and overcrowding, and improve patient satisfaction.

Medical directives are pre-authorized orders that allow healthcare providers to perform specific procedures or treatments on patients who meet pre-defined criteria.

As shown in Figure 1, utilizing medical directives during the nurse assessment stage can help reduce delays caused by labs and imaging. However, it's important to note that medical directives can only be used if they have been approved and implemented by the hospital and physicians. They are generally not applicable in situations where multiple symptoms, complex symptoms or contraindications exist.

A report from the Auditor General of Ontario revealed inconsistencies in the use of medical directives across Ontario hospitals. While all audited facilities had medical directives in place, the number varied significantly, ranging from 9 to 37 per hospital, and some hospitals used them for very specific situations, like low blood sugar. Although hospitals don't centrally track medical directive usage, evidence suggests some facilities utilize them more frequently than others. For example, one hospital reported initiating care with medical directives in approximately 50% of emergency department visits.

To address the inconsistent use of medical directives, we must understand the underlying reasons. According to Kim Alvarado, several factors influence their implementation, including:

- Nurse confidence and willingness to assume responsibility.
- The amount of new learning required to implement the directive and any additional paperwork.
- Perceived usefulness of the medical directive.
- Physician support for nurses' use of the directives.
- Frequency of encountering patients for whom the directive is applicable.

To increase the utilization of medical directives within the William Osler Health System, they could be digitized and integrated with an AI-powered feature on the hospital website. Making use of AI on organization-specific information would require the application of Retrieval-Augmented Generation (RAG), to be more specific. This AI-driven automation system (Med-Direct) would provide consistent support for decision-making, thereby increasing nurses' confidence in using the directives.

Med-Direct can also assist nurses with the learning process and automate the necessary documentation.

Med-Direct facilitates data collection regarding the number of medical directives used. Comparing this data with wait times, patient volume, and case severity will provide clear insights into the effectiveness and usefulness of medical directives.

AI-enhanced decision-making algorithms significantly reduce the risk of errors, which can increase physician confidence and encourage greater support for nurses using the directives.

The frequency of encountering patients who meet the criteria for specific directives becomes less of a concern, as nurses are supported by the AI system.

It's important to note that Med-Direct is a decision support system and does not replace the necessary training for implementing medical directives

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User Experience and Flow

User Experience

First-time Users of Med-Direct at Brampton Civic Hospital ER

The hospital administration announced the implementation of a new clinical decision support system, Med-Direct, designed to improve consistency and efficiency in the use of medical directives. After being introduced to Med-Direct, two ER nurses decided to try using it to validate its accuracy and provide feedback to the hospital administration.

Experience 1:

A 22-year-old male ER patient, John Jones arrived with the following presenting complaints: pain in the forearm. The affected area was deformed and swollen, which limited the patient's range of motion.

John was Nurse Jane’s first patient and was prompted to login after she opened the William Osler Health System HIS webpage. She types in her username, password and clicks the Login button.

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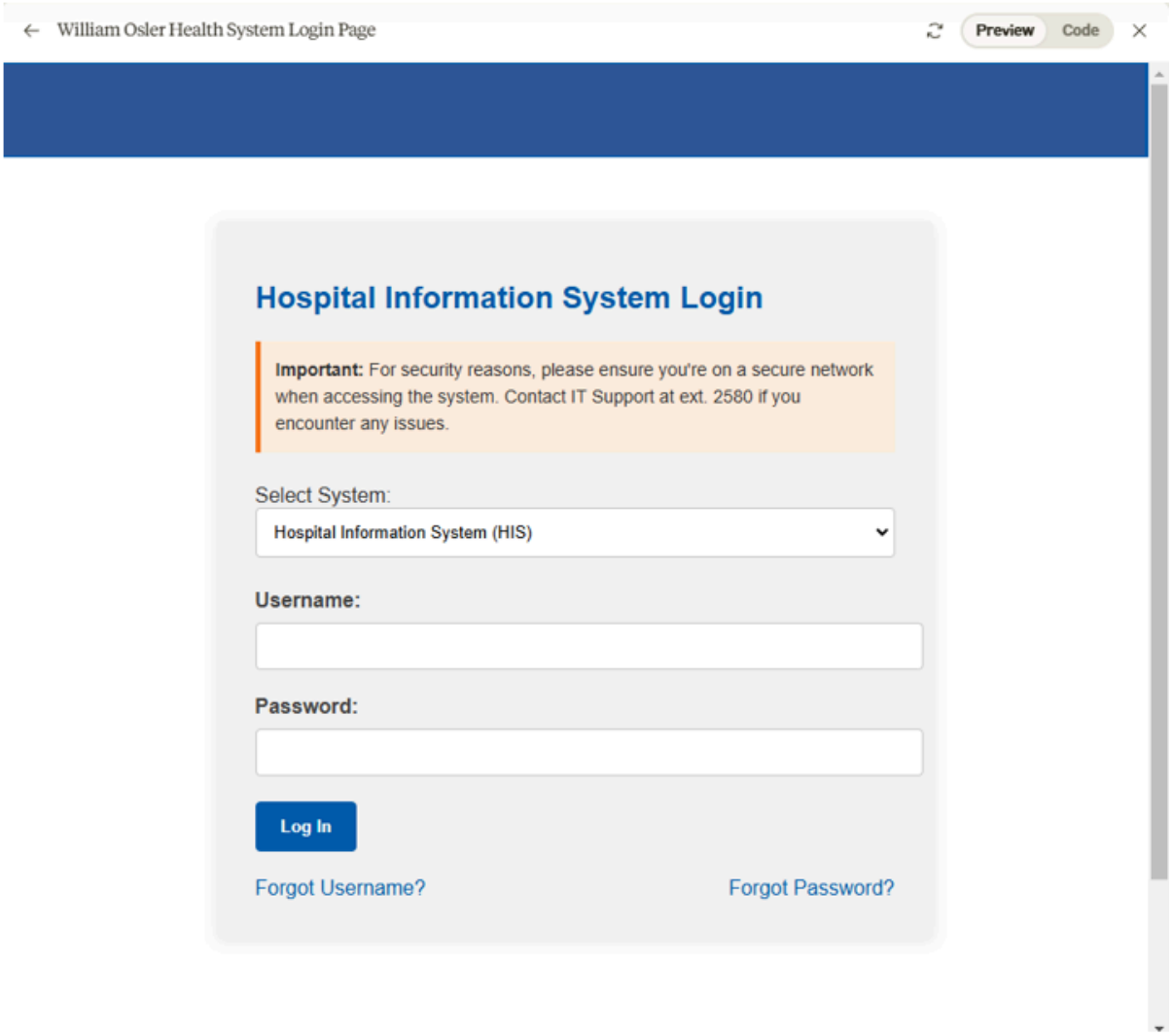

She is directed to the next page where she chooses her primary duty, Nurse assessment.

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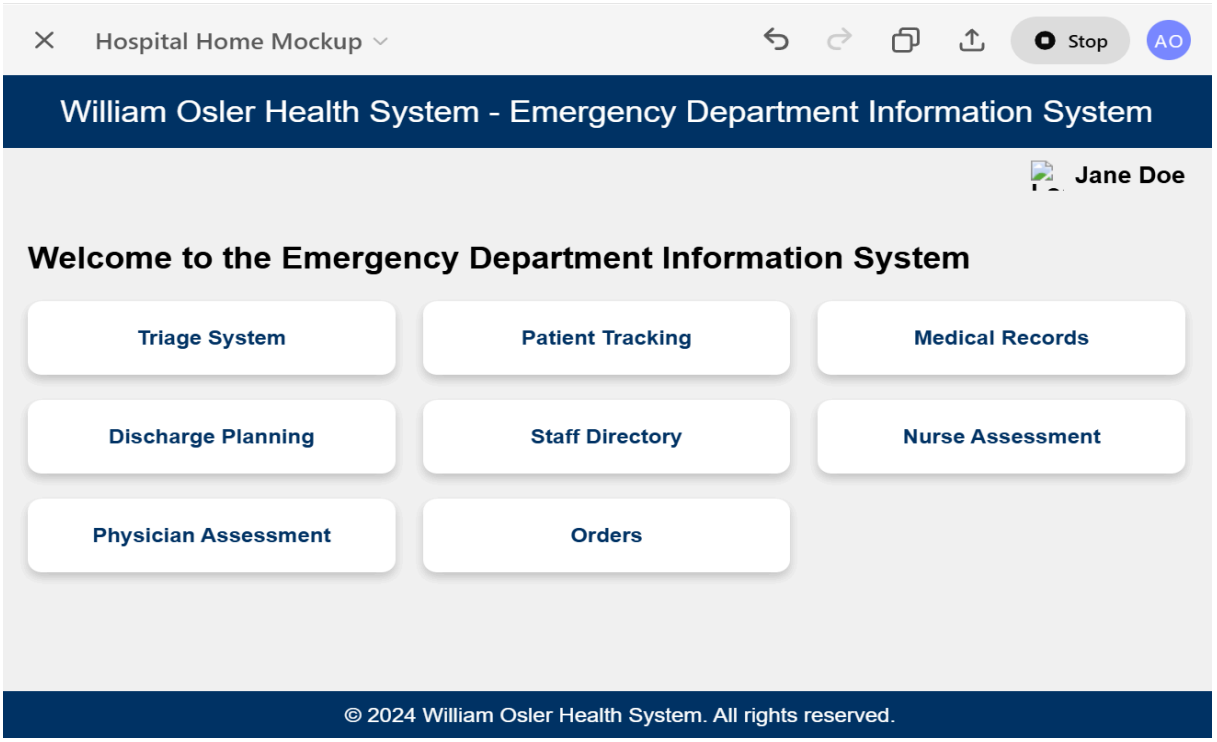
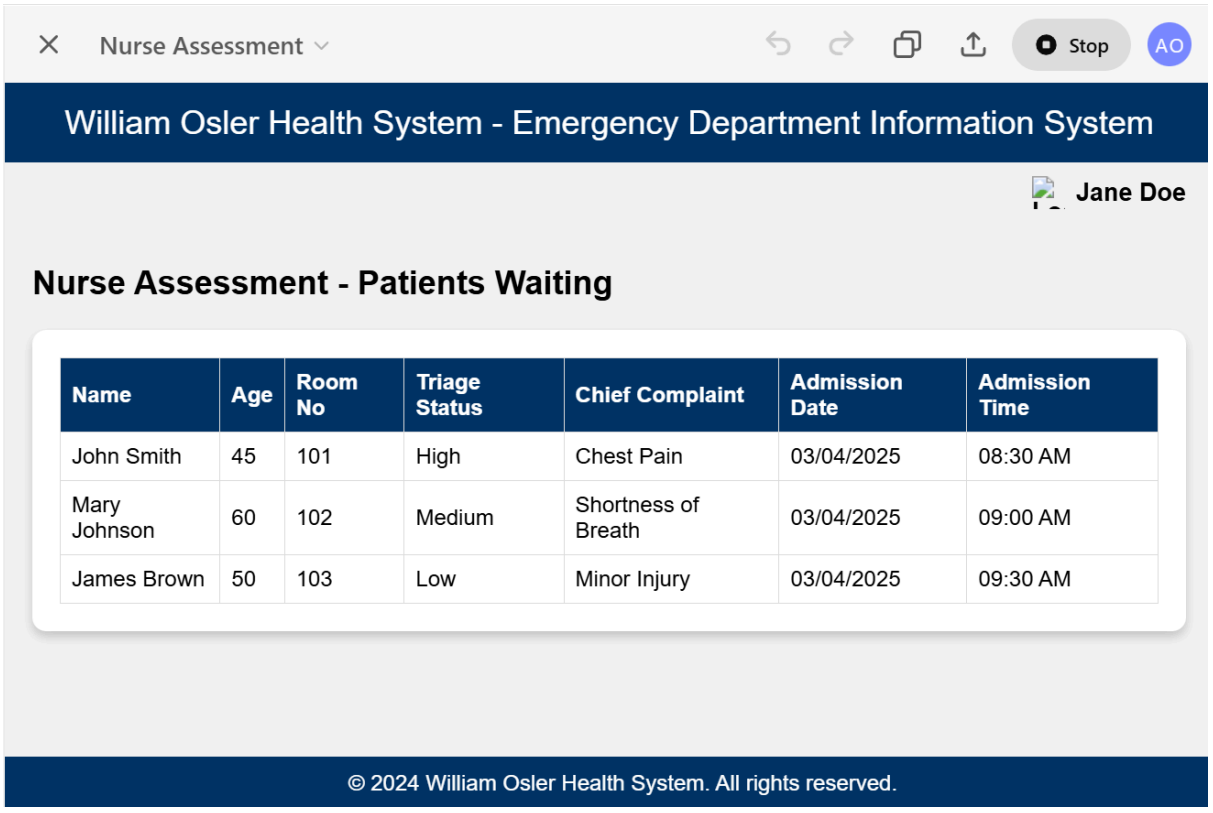


The list of patients awaiting nurse assessment appears after she clicks the button.



Nurse Jane clicks on the name of John to review and edit his records.

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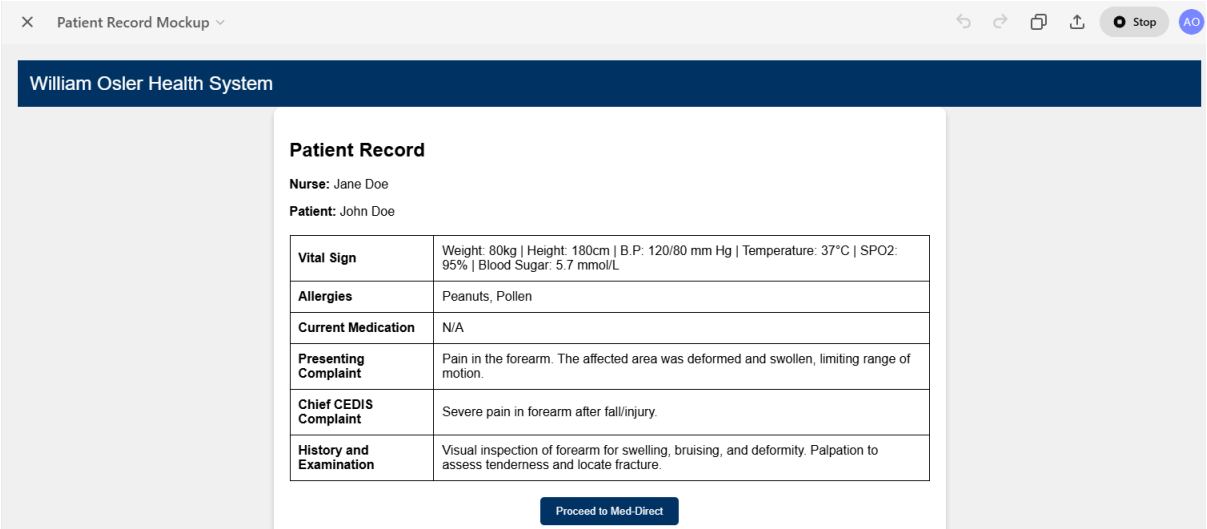


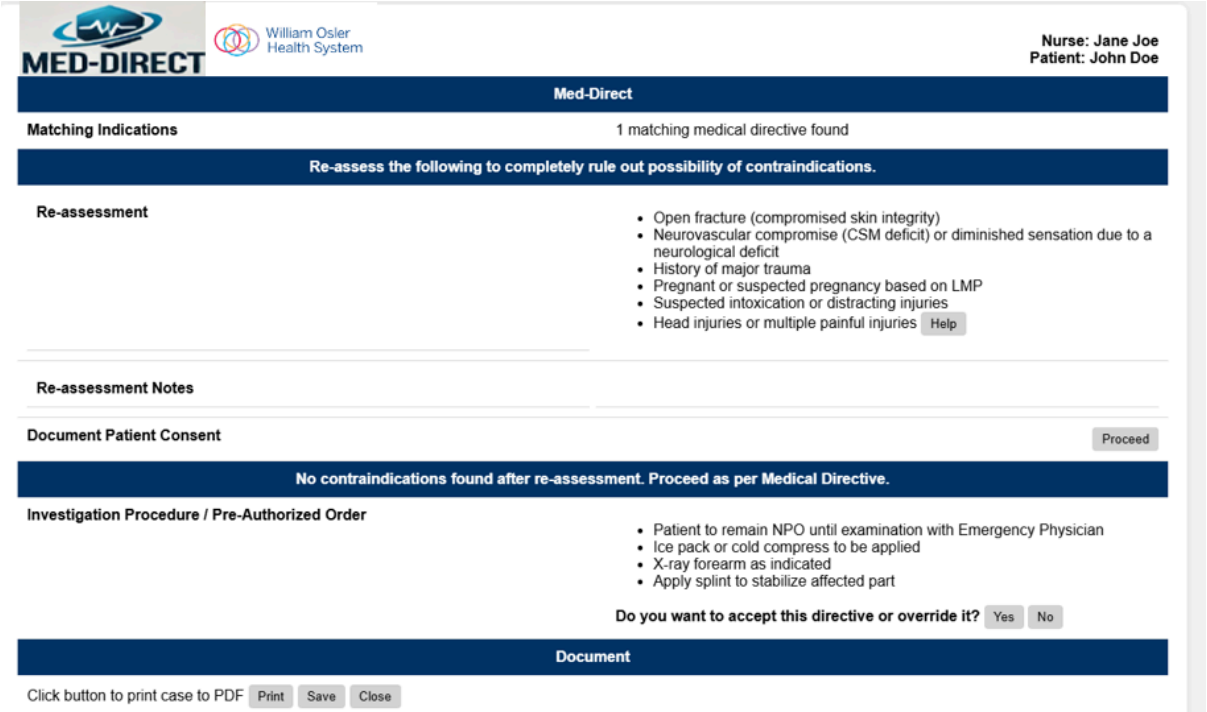
After getting to the patient record page, she was asked to enter the presenting complaint, CEDIS complaint, vital signs, medical history and examination notes. She entered the requested patient details.

Upon assessing the affected area, nurse Jane suspected a forearm fracture due to the presence of bony tenderness, particularly after assessing for scaphoid tenderness.

Start of Med-Direct

Med-Direct initiates its first operation using a RAG application. The nurse triggers a query to the system by clicking "Proceed to Med-Direct". The system searches the vector database for the most relevant text chunks that match the query, which, in this case, is the patient's complaint. This ensures that only the most relevant medical directive is retrieved.

Med-Direct provides a count of relevant medical directives associated with the triggered query, returning a result of 1, as indicated in the "Matching Indications" section.



NB. Medical directives are pre-authorized orders that allow healthcare providers to perform specific procedures or treatments on patients who meet pre-defined criteria.

The pre-defined criteria which when met, allows a healthcare professional to initiate a procedure is known as Indications

Pre-defined criteria which when met, prevents a healthcare professional from initiating a procedure is called contraindication.

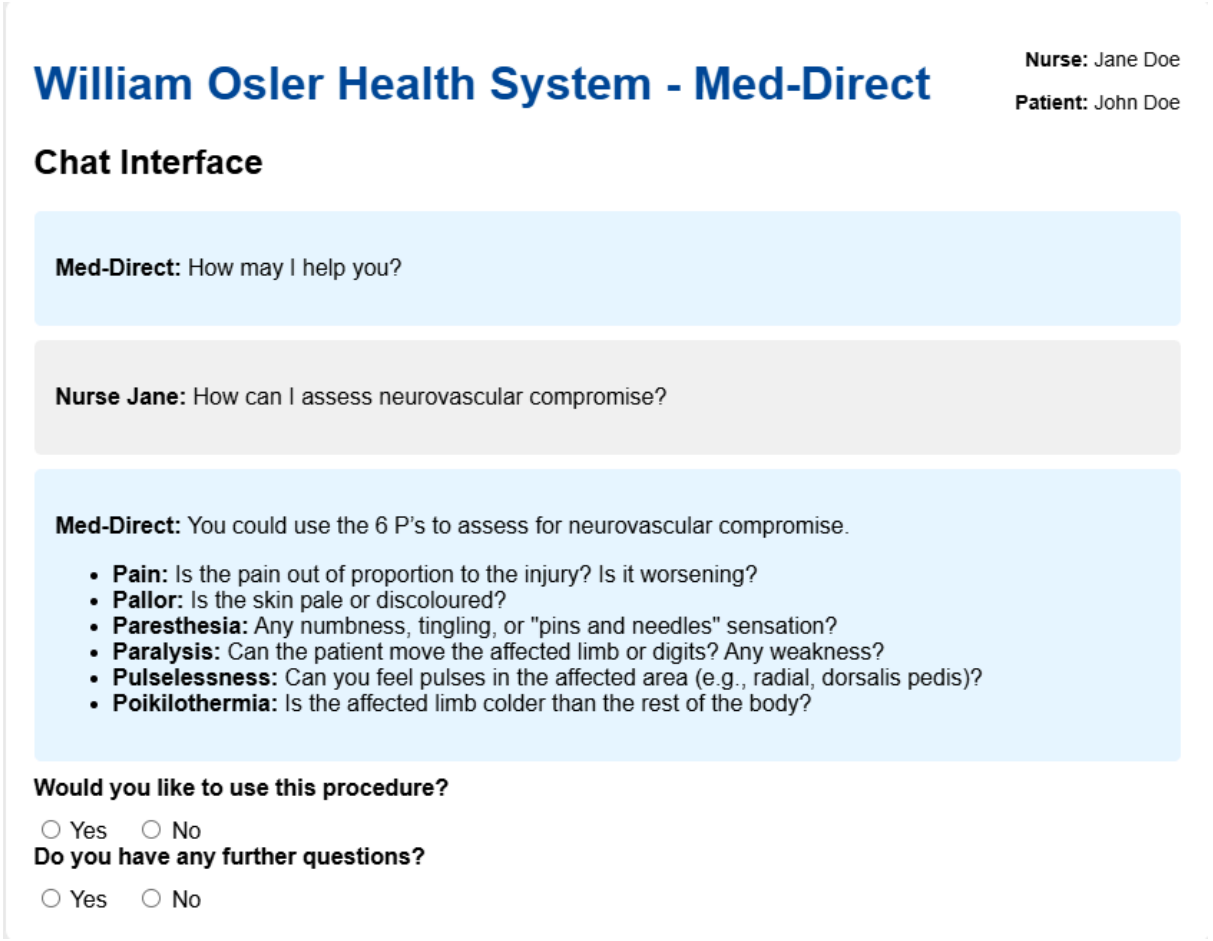
Second Med-Direct AI feature operation:
The system utilizes the RAG application to retrieve relevant contraindications and checks if any match the patient's complaints. If no match is found, it prompts the nurse to reassess, unless this has already been done.

Finding no contraindications, Med-Direct prompted the nurse to ask additional questions (Reassessment) to completely rule out the following contraindications:

- Open fracture (compromised skin integrity)
- Neurovascular compromise (CSM deficit) or diminished sensation due to a neurological deficit (e.g. CVA, altered level of consciousness, etc.)
- History of Major trauma
- Pregnant or suspected pregnancy based on date of LMP on females of child bearing years
- patient Suspected intoxication or has distracting injuries and is unable to follow direction, maintain motor control, or is un-cooperative
- Head injuries or multiple painful injuries

Third AI feature operation: Utilizes a RAG application chatbot to retrieve procedures from documented SOPs, assisting the nurse with less frequently occurring procedures.

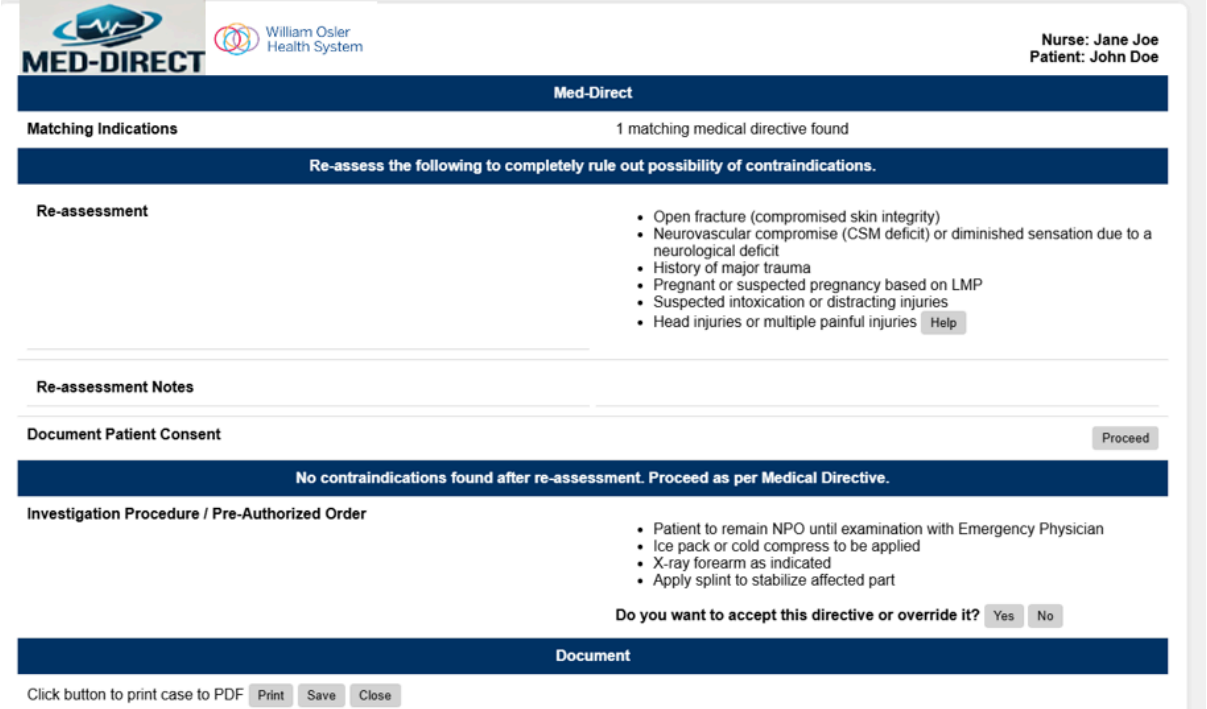
The nurse was not very familiar with assessing neurovascular compromise, as she encountered such cases infrequently. She saw a blue help button in the lower left corner of the re-assessment section and clicked it. A display window enlarged, asking, "How may I help you?" The nurse asked how to assess neurovascular compromise. Med-Direct consulted the hospital's SOPs and presented the following suggestion:



You could use the 6 P's to assess for neurovascular compromise.

- Pain: Is the pain out of proportion to the injury? Is it worsening?
- Pallor: Is the skin pale or discoloured?
- Paresthesia: Any numbness, tingling, or "pins and needles" sensation?
- Paralysis: Can the patient move the affected limb or digits? Any weakness?
- Pulselessness: Can you feel pulses in the affected area (e.g., radial, dorsalis pedis)?
- Poikilothermia: Is the affected limb colder than the rest of the body?

The ER nurse accepted the suggested Procedure. The nurse was asked if she had any further questions and she clicked No to proceed back to the previous page.



Forth RAG application operation: compares answers of reassessment notes with retrieved contraindications

Nurse Jane continues to complete the re-assessment. Med-Direct allowed the nurse to input her notes after assessing all potential contraindication**. No contraindications were found for this specific case.**

The nurse proceeded to the next step, where she was asked to obtain the patient's consent to apply the directive. She documented the response in the corresponding space on the right.

Last RAG application: retrieves pre-authorized orders from system

The system then displayed the pre-authorized order:

- Patient to remain NPO until examination with Emergency Physician has been achieved
- An Ice pack or cold compress is to be applied to injuries less than 8 hours old
- X-ray forearm as indicated by examination
- Apply splint as needed to stabilize the affected part

The system presented the nurse with the option to accept or override the pre-authorized order, in accordance with the physician's medical directive. The nurse accepted the order and instructed the system to document the event (print and save to pdf). Med-Direct notified the ER physician of the use of specified medical directive's and updated its internal KPI tracking system.

Experience 2:

A 14-year-old male paediatric ER patient arrived with the following presenting complaints: shortness of breath, chest pain, wheezing, and cough.
The ER nurse suspected asthma and questioned the boy and his mother about any history of the condition. His mother confirmed that he had experienced asthmatic attacks in the past.

The ER nurse had already logged in and was at the Emergency patient List section. She clicked on the name of the patient and was asked to enter the presenting complaints, CEDIS complaint, vital signs, medical history, and nurse assessment notes. She entered the requested patient details.

Med-Direct matched the complaints with existing medical directives and found one match. The entered vital signs were validated based on range, format, and characters. The system verified the nurse's authorization before proceeding.

The system checked the examination notes and medical history for matching contraindications. Finding no contraindications, Med-Direct prompted the nurse to conduct re-assessment by asking additional questions to completely rule out the following contraindications:

- History of any acute or chronic condition other than asthma, including cardiac conditions.

The nurse questioned the mother about any acute or chronic cardiac conditions in the boy's medical history. His mother mentioned arrhythmias. After the nurse entered this information into Med-Direct, the system alerted her to the contraindication and suggested waiting for the initial physician assessment.

The nurse agreed with the system's suggestion. Med-Direct recorded this as a case not requiring a medical directive.

Both ER nurses appreciated Med-Direct's ability to analyse and interpret unstructured data, identify relevant conditions, and support nurses in the decision-making process, thereby promoting greater consistency.

User Flow

https://app.mural.co/t/albert3150/m/albert3150/1740023955838/dad811d7dd01f5a19f35221eb8bfff7d5ded1e06?sender=u3aef876b7fca2c8fd42b2096

Mockup

Here is a link to Figma design page:
https://www.figma.com/design/F74lEaAq61u9PsFMgpDZyB/Med-Direct?node-id=0-1&p=f&t=JG5xAVGHURtBhDtx-0

Prototype

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Link to Figma prototype:
https://www.figma.com/proto/F74lEaAq61u9PsFMgpDZyB/Med-Direct?node-id=2-399&p=f&t=2TpPdVmPvLctqAgu-1&scaling=scale-down&content-scaling=fixed&page-id=0%3A1

Requirements

Functional Requirements

No.	Requirement	Priority
1	Prompts user about matching directives or if there are no matching medical directive for specific case.	P0
2	Notifies user of counterindication if any is found. Prompts user for ask further questions if no counterindications are found.	P0
3	Provides decision support based on user input.	P0
4	Allows user to login to check if they are authorized users of specified medical directives	P1
5	Allows user to accept or decline suggested medical directive	P1
6	Prompts user if vital signs or relevant historical data is missed or not valid	P1
7	Prompts user to document patient consent.	P1
8	Allows user to pull counterindication from hospital information system based on medical history	P2
9	Allows user to document details of medical directive used.	P2
10	Allows user to search for related medical directive documents and standard assessment procedures for manual verification and reference purposes.	P2
11	Allows users (nurses) to keep track of certification/ authorizing to make use of medical directives.	P2
12	Allows user to track frequency of use for each kind of medical directive, total directives, count of overrides and total ER cases, to help analyse efficiency of Medi-Direct.	P3
13	Sends message to authorizing physician when medical directive is used	P3
14	Aid in training nurses on future medical directives	P3
15	Allows user to type CEDIS or presenting complaint, as they start typing, a drop down of matching CEDIS complaint appears.	P3
16	Allows user to ask procedure based questions from hospital SOP's	P3

FAQ

What will the onboarding process for Med-Direct entail?

Users can log into the Med-Direct on the William Osler Health System plat form using their existing log in credentials. New employees will have to obtain access from the hospital administration.

How will this feature reduce wait time in the ER?
With the enhanced AI decision making support, We expect that hospitals will optimize the use of medical directives which should reduce delays due to lab results and diagnostic imaging.

How will this feature help improve patient safety?
Med-Direct reduces the risk of human error and ensures that care is evidence-based. Making use of medical directives could also ensure patients are treated in a timely manner.

How will this feature help drive revenue for William Osler Health system administration and Physicians?
Government programs such as the Pay for Results (P4R) were previously created to incentivise hospitals to increase their performance in accordance to key performance indicators such as wait time.

The use of Med-Direct could also help reduce operation cost by reducing the occurrence of unnecessary tests due to human error.

How do we ensure we have the right return of investment on this project?
Our solution will make use of NLP models to extract information from unstructured triage clinical notes and electronic health records. This allows the model to understand and provide relevant suggestions based on established algorithms.

We expect to gain valuable data that will help improve patient satisfaction, reduce operational costs, and drive revenue from government-incentivized programs. However, a complete justification of return on investment will depend on conducting a thorough cost-benefit analysis.

Measuring success

#	Outcome	Measure	Current	Target	Priority
1	Reduce wait time	Total time spend at hospital			0
		Time spent waiting for labs			
2	Optimization of use of medical directives	% of medical directives used out of total ER cases			0
3	Reduced administrative work/documentation	count of medical directives used			2
4	Reduced stress during peak hours	% reduction in patient count during peak hours			1

5	Increase in revenue	% Revenue increase per % decrease in wait time			1
		% Revenue increase per % reduction in un-necessary test			

Milestones and Timelines

Item	Timeline	Exit Criteria
Phase 1: Requirements & Design (5 weeks)		
User Flow and Wireframes	1 week	User flows and wireframes for key CDSS functionalities (e.g., patient data input, risk assessment display, treatment recommendations) completed. Focus on ER workflow integration.
Run Validation Interviews	1 week	Feedback gathered from ER physicians, nurses, and IT staff on user flows and wireframes. Documented feedback and incorporated into design.
Run MVP Experiment	1 month	Meets minimum criteria for success.
High-Fidelity Design	2 weeks	High-fidelity mockups of the CDSS interface, incorporating stakeholder feedback. Emphasis on usability and clear presentation of information.
Phase 2: Development & Testing (12 weeks)		
Develop Core CDSS Engine	4 weeks	Core AI/ML models for risk assessment, diagnosis support, and treatment suggestions developed and unit tested. Focus on accuracy and reliability. Initial integration with test data.
Integrate with EHR (Test Environment)	2 weeks	CDSS integrated with a test environment of the hospital's Electronic Health Record (EHR) system. Data exchange verified. Privacy and security protocols implemented and tested.
Internal Testing and Validation	4 weeks	Rigorous testing of the CDSS in the test EHR environment by clinical staff. Focus on usability, accuracy, and performance. Documentation of test cases and results. Address any bugs or issues.
Scalability, Performance & Load Testing	2 weeks	System tested for handling increased patient load, concurrent users, and response times under stress conditions. Optimizations made to ensure stability.
Phase 3: Pilot & Deployment (8 weeks)		
Pilot Deployment (Limited ER Area)	2 weeks	CDSS deployed in a limited area of the ER (specific nurse assessment area at Brampton Civic Hospital, with a small group of nurses and physicians). Close monitoring of system performance and user feedback.

Pilot Evaluation and Refinement	2 weeks	Evaluation of the pilot deployment based on predefined metrics (e.g., time to diagnosis, treatment accuracy, user satisfaction). Refinement of the CDSS based on evaluation results and user feedback.
Feature Enhancements Based on Pilot Feedback	2 weeks	Updates made to improve core functionality and address any usability or performance issues before wider rollout.
Full Deployment	2 weeks	CDSS deployed to all William Osler Health System hospitals. Training provided to all staff. Ongoing monitoring of system performance and user feedback.
Phase 4: Post-Deployment & Iteration (Ongoing)		
Performance Monitoring & Analysis	Ongoing	Continuous monitoring of CDSS performance, including accuracy, usage patterns, and impact on clinical outcomes. Regular reporting and analysis of data.
Post-MVP Scaling & Optimization	6 weeks	Refinement of system architecture to handle higher patient volumes, improve processing speeds, and optimize real-time data exchange with EHR.
New Functionality Development	8 weeks (Rolling Basis)	Implementation of additional features based on evolving clinical needs, including AI-driven decision support improvements and expanded treatment recommendations.
User Feedback & Feature Enhancements	Ongoing	Regular collection of user feedback. Prioritization and development of new features and enhancements based on feedback and evolving clinical needs. Iterative improvement of the CDSS over time.
Regulatory Compliance & Updates	Ongoing	Regular review and updates to ensure compliance with relevant regulations and guidelines. Maintenance of documentation and audit trails.

Appendix

1. Research plan
2. Research Synthesis
3. User and Use-case prioritization
4. User experience document
5. User flow
6. Mockups
7. Prototype on Figma

References

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