The **Surg-e-Screener HF** Tool:

Improving Heart Failure Recognition using Electronic Health Records

e-Learning Module

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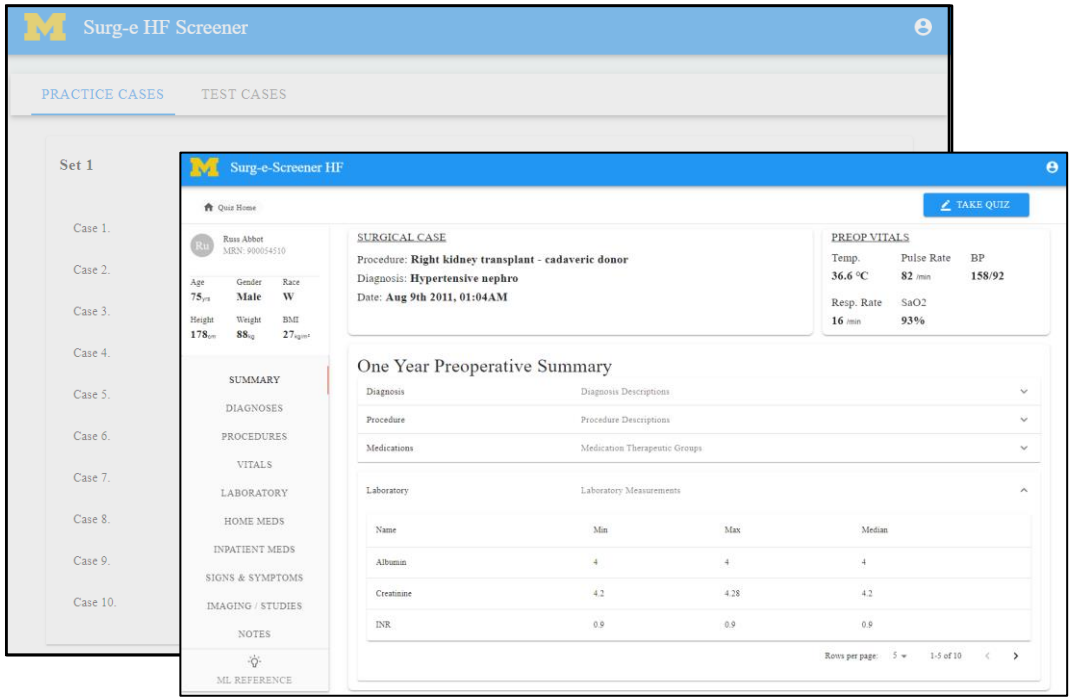
The Problem

Treatments for **heart failure** (HF) proven to extend & improve quality of life are limited by clinicians' ability to diagnose the disease in **early stages**.

The Problem

Unrecognized or untreated heart failure is the single greatest risk factor for cardiovascular complications and mortality after **major surgery**.

The Solution: Surg-e-Screener HF

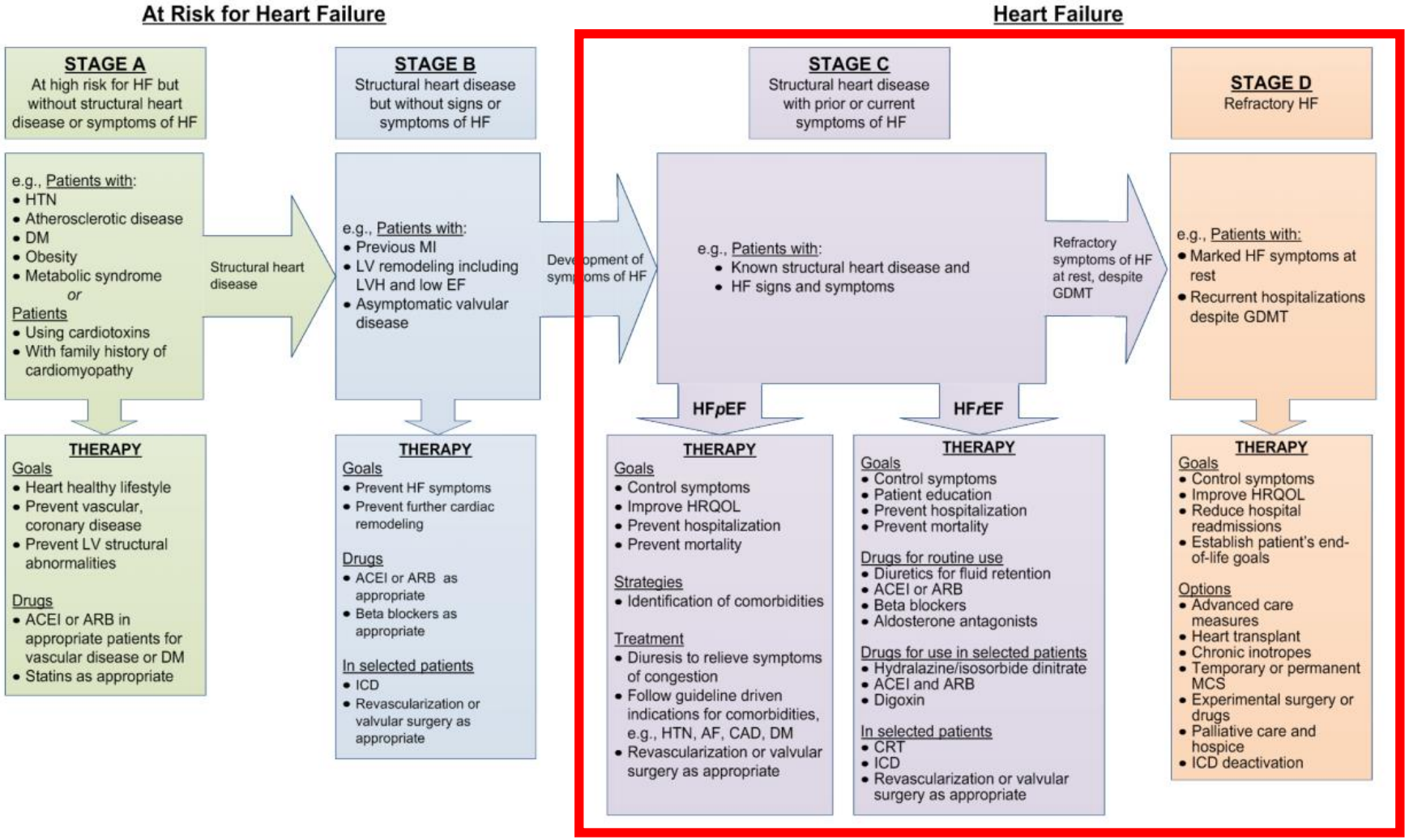


Surg-e-Screener HF:
Automated screening & educational tool

Education & Training –

- It is a quiz-based webapp to **improve HF recognition** with surgical cases in EHR
- It provides a report after completing quizzes to ***compare*** your clinical judgment to **a pane of HF experts**
- It is designed to **augment clinicians' ability** using EHR data and machine learning (ML) reference

Chronic Heart Failure Definition for this Tool



For purposes of this tool, **Chronic HF** defined as:

- **Chronic**:
  Signs +/- symptoms or underlying pathophysiology persistent for ≥ 3 months (with onset defined as the *start* of this ≥ 3 month period)
- **HF**:
  ACCF/AHA Stage C or D (*prior* or current symptoms + structural heart disease)

Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology.* 2013;62(16):e147-239.

Purpose of this study

To understand how EHR-based *heart failure (HF) recognition* can be improved as aided by the **Surg-e-Screener HF** tool.

Case Review Process

1. Case Reviews

Assume you are *a preop physician* reviewing the patient's medical history prior to surgery in order to identify factors pertaining to presence/absence of HF

- Previous HF diagnoses (simplest way to detect, but occasionally inaccurate)
- Signs & symptoms, labs, studies/imaging, medications, clinical notes.

2. *Pre-test*: HF Recognition Quiz

For the first 10 cases, you use EHR data to decide if a patient had HF (chronic ACC/AHA Stage C or D) before the start of the surgery.

3. ML Reference

After completing the quiz, you have access to the ***Machine Learning (ML) reference,*** ML performance indicators and a list of risk factors ranked by an algorithm.

4. *Post-test*: HF Recognition Quiz

For the next 10 new cases, you use EHR data **AND** the ML reference to decide if the patient had HF (chronic ACC/AHA Stage C or D) before the start of the surgery.

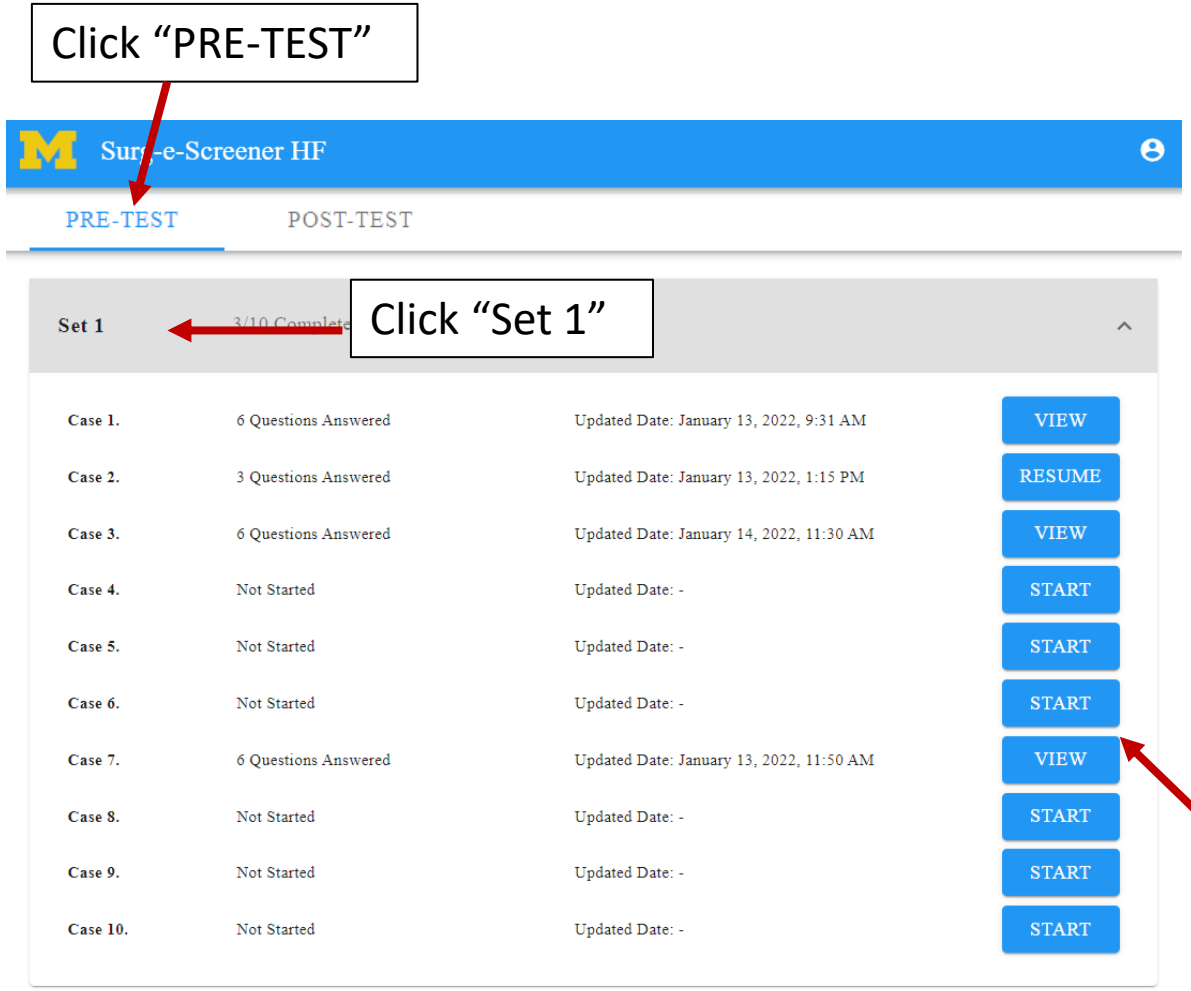
5. Expert Review Comparison

After completing 20 surgical cases, you can access a result report, comparing your HF decision to pre-determined answers and a short case summary by HF experts.

How to use the tool:

Step-by-step Guide

Step 1. Case Reviews



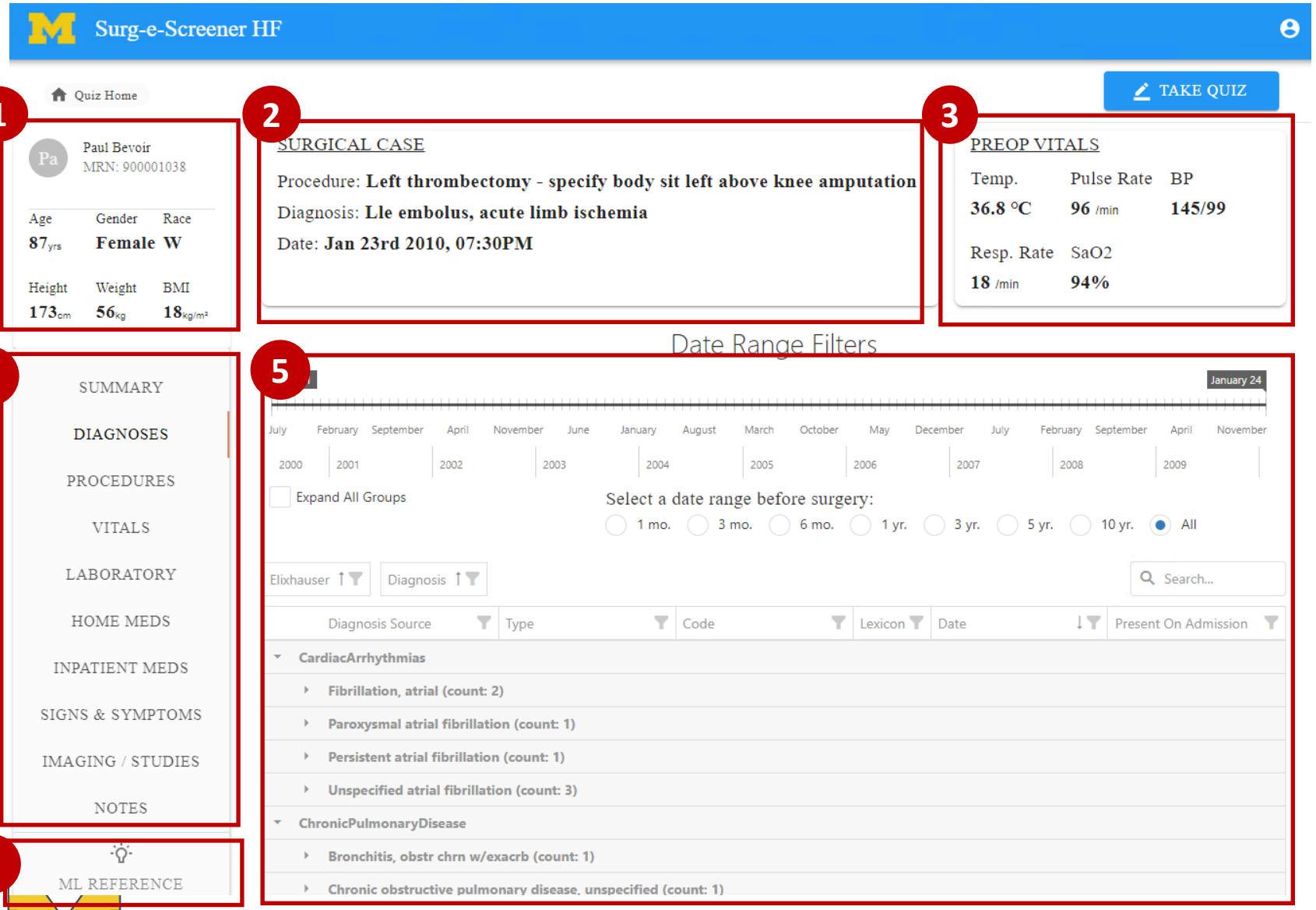
Check your assigned cases

- 10 surgical cases are assigned to ***Pre-Test*** and 10 surgical cases are in ***Post-Test***.
- Click ***Pre-Test*** to review 10 surgical cases.
- Click the ***Start*** button to begin your case review. The button indicates your status.

Status of your progress:

START	No questions completed.
RESUME	Partially answered questions, not yet completed.
VIEW	Completed questions. You can *only* view the case.

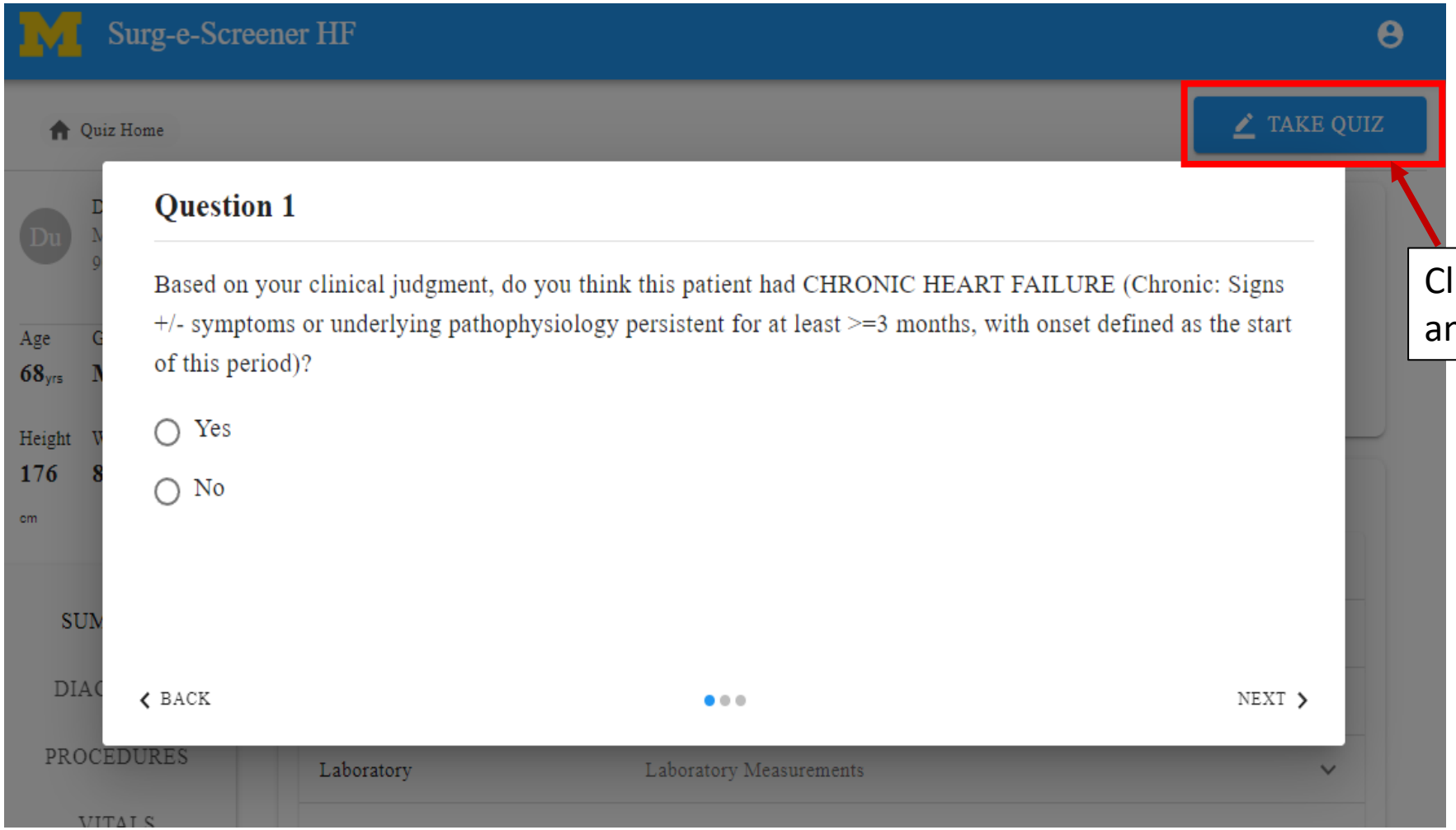
Step 1. Case Reviews: Dashboard



Key components

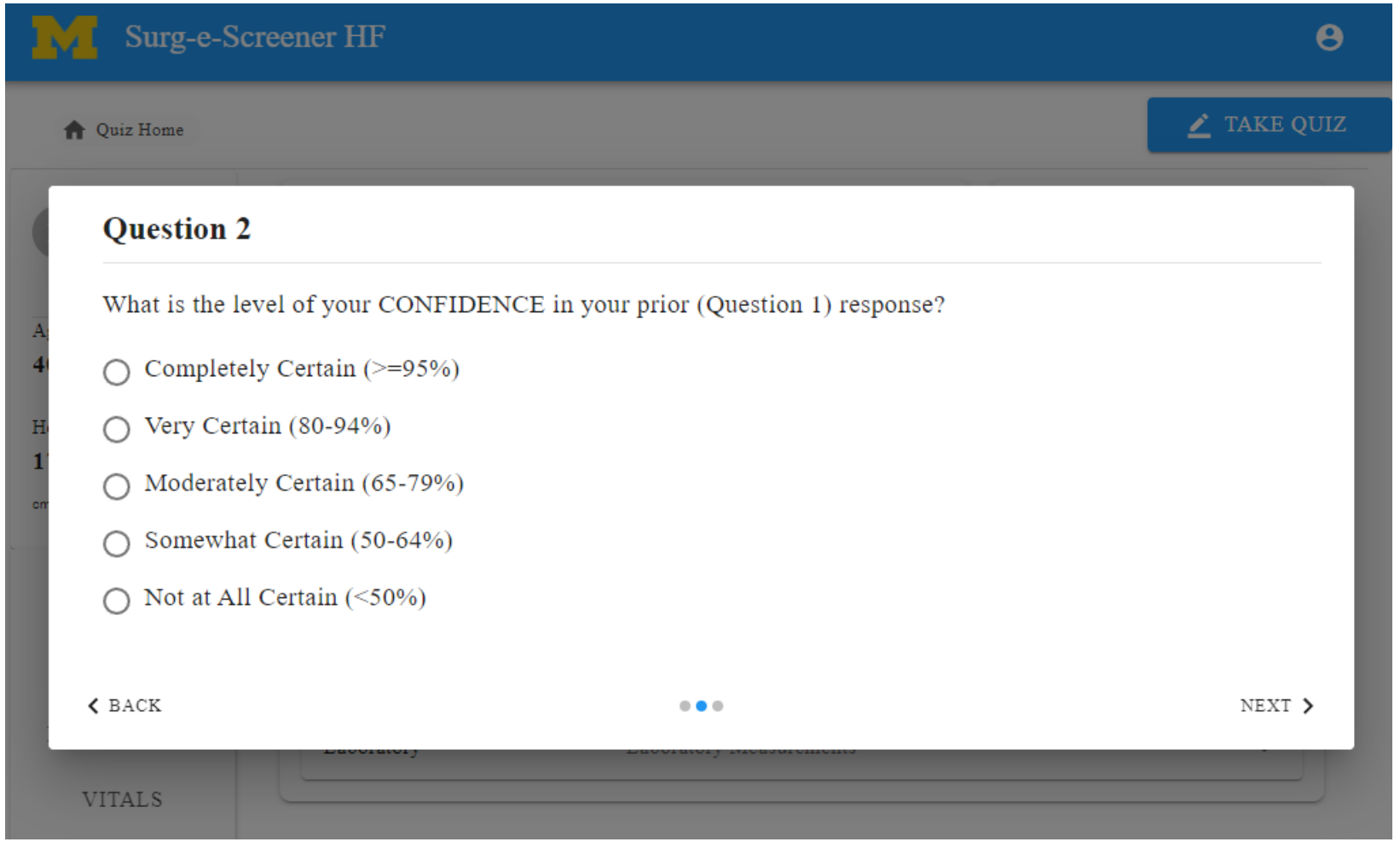
1. Demographics
2. Surgical Case
3. Preoperative Vitals
4. Subject Domains
5. Date Filter & EHR data
6. ML reference

Step 2. *Pre-test*: HF Recognition Quiz

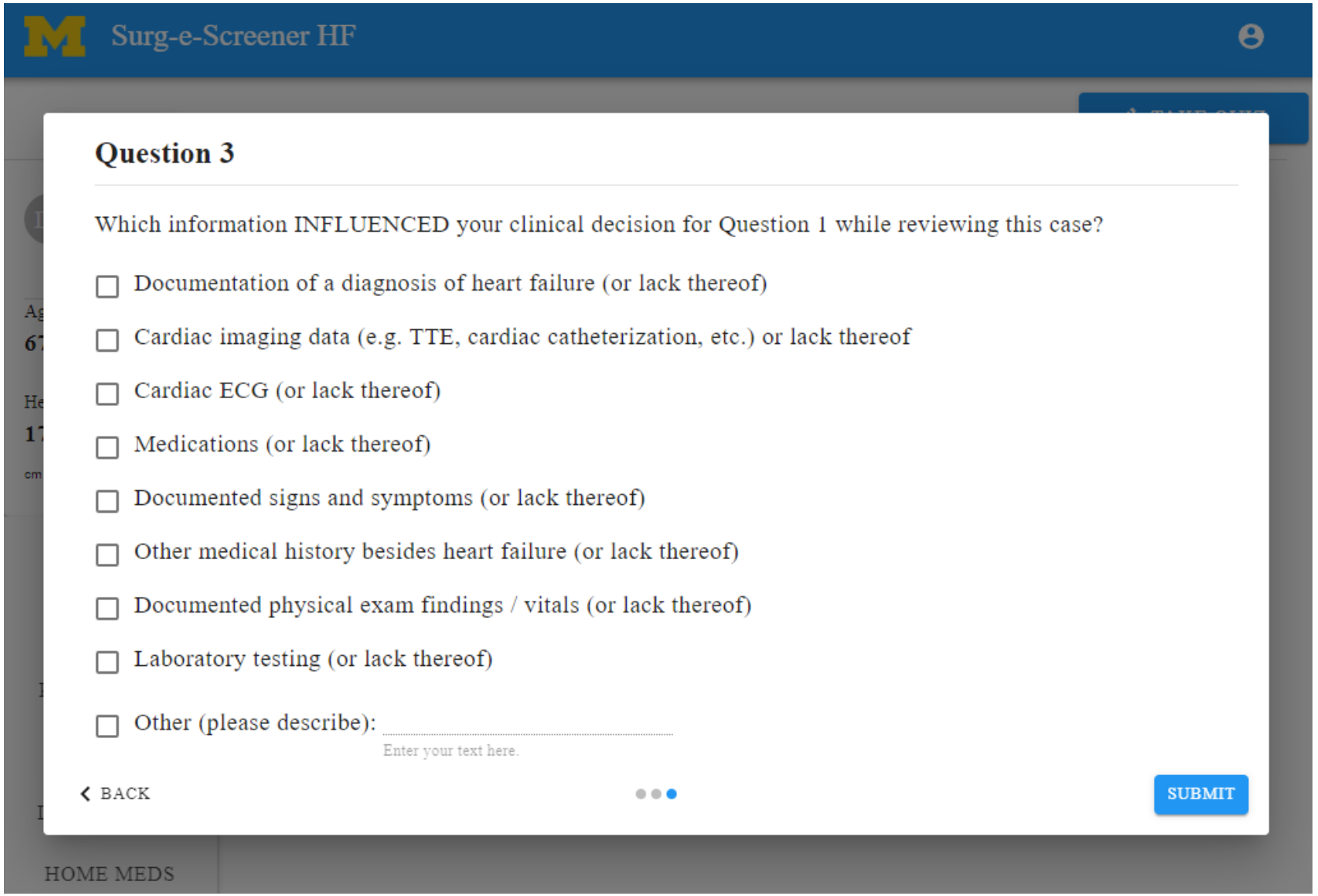


Click “Take Quiz” to answer your decision

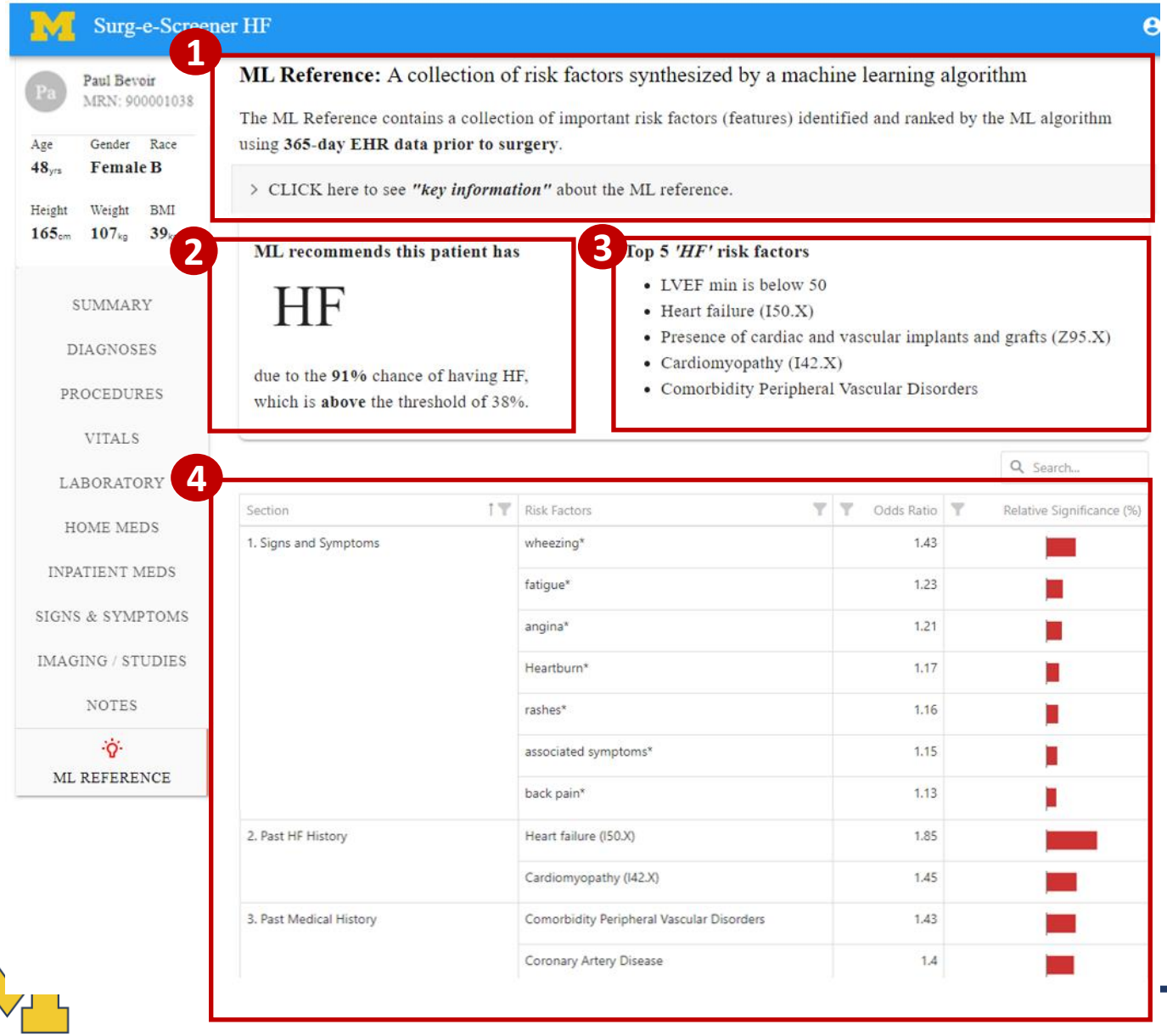
Step 2. *Pre-test*: HF Recognition Quiz



Step 2. *Pre-test*: HF Recognition Quiz



Step 3. Machine Learning (ML) Reference



Key components

1. The ML Reference description
2. HF or No HF
3. Top 5 HF risk factors
4. Risk factors calculated and ranked by ML algorithms

Using the Machine Learning (ML) Reference

Key HF features are identified and ranked in each category

Odds Ratio

- **OR = 1:** No Effect
- **OR > 1:** Higher Odds to HF
- **OR < 1**: Lower Odds to HF

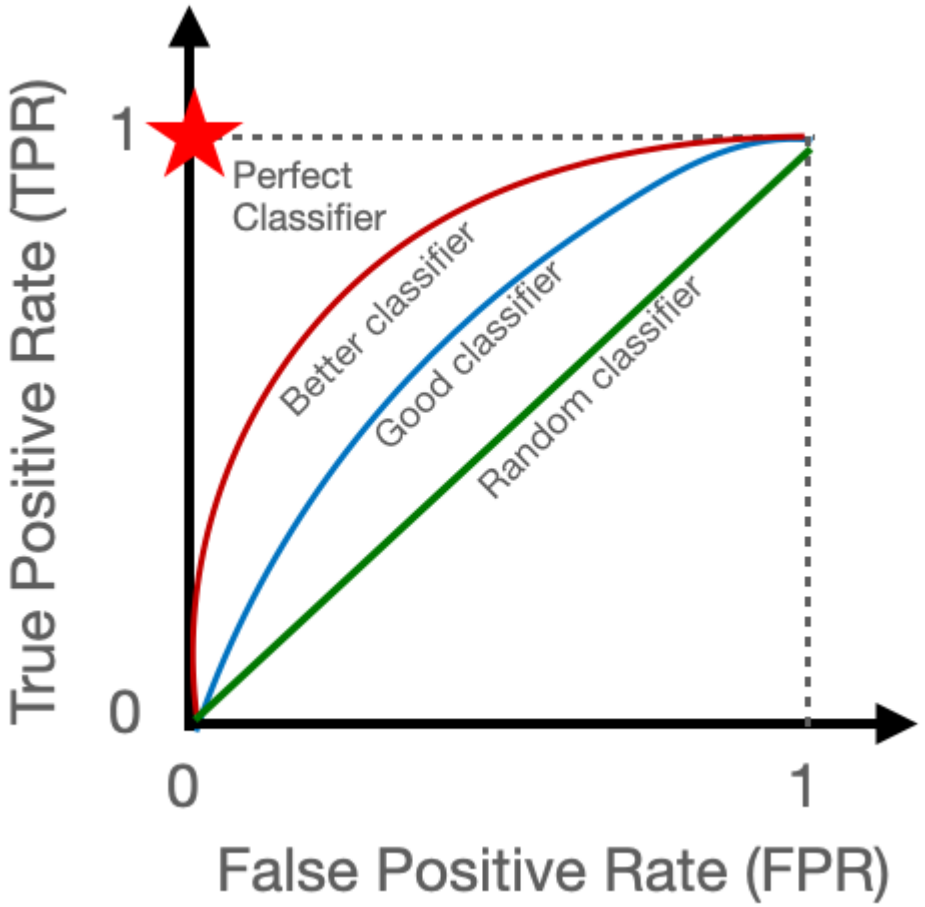
Risk Factor Relative Significance (%)

- Positive assoc. with HF in **red**, meaning a patient is more *likely* to have chronic HF
- Negative assoc. with HF in **green**, meaning a patient is *less likely* to have chronic HF

Category	Feature Name	Odds Ratio	Relative Significance (%)
Signs and Symptoms	Acute Pain*	1.12	0.76
	angina*	1.21	1.30
	associated symptoms*	1.15	0.95
	back pain*	1.13	0.85
	calf pain*	0.91	-0.64
	cough*	0.94	-0.40
	Dizziness*	1.05	0.34
	dry skin*	1.18	1.17
	dyspnea on exertion*	1.21	1.33
	eye pain*	1.20	1.27
	fatigue*	1.23	1.44
	Heartburn*	1.17	1.09
	nervousness*	0.88	-0.89
	photophobia*	1.16	1.04
	rashes*	1.16	1.03
	rest pain*	0.92	-0.56
	stridor*	1.16	1.04
	tarry stools*	0.90	-0.75
	urinary symptoms*	1.18	1.12
	wheezing*	1.43	2.44
Past HF History	Cardiomyopathy	1.45	2.55
	Heart Failure	1.85	4.25
Past Medical History	Disorders of fluid, electrolyte, and acid-base balan	1.14	0.91
	Other and unspecified anemias (285.X)	1.11	0.69
	Cardiac dysrhythmias (427.X)	1.26	1.61
	apnea*	0.93	-0.52
	Comorbidity Chronic Pulmonary Disease	1.13	0.84
	Comorbidity Diabetes Complicated	1.28	1.73
	Comorbidity Hypertension Complicated	1.32	1.92
	Comorbidity Hypertension Uncomplicated	1.28	1.71
	Comorbidity Peripheral Vascular Disorders	1.43	2.45
	Comorbidity Pulmonary Circulation Disorders	1.24	1.49
	Comorbidity Valvular Disease	1.28	1.72
	Coronary Artery Disease	1.40	2.31
	Other anemias (D64.X)	0.90	-0.73
	Other disorders of fluid, electrolyte and acid-base l	0.95	-0.36
	Nicotine dependence (F17.X)	1.12	0.80
	Other anxiety disorders (F41.X)	0.84	-1.16
	Essential (primary) hypertension (I10.X)	1.22	1.38
Past Medical History	Gastro-esophageal reflux disease (K21.X)	0.85	-1.10
	Abnormalities of breathing (R06.X)	1.31	1.87
	Abnormal findings on diagnostic imaging of lung (R	0.89	-0.78
	Abnormal results of function studies (R94.X)	0.92	-0.55
	Smoking Classification - Former Smoker	0.91	-0.67
	Personal history of malignant neoplasm (Z85.X)	0.84	-1.22
Past Surgical History	Presence of cardiac and vascular implants and gra	1.77	3.92
Medications	ANTIBIOTICS	1.13	0.83
	ANTIVIRALS	0.88	-0.91
	AUTONOMIC_DRUGS	1.11	0.72
	MUSCLE_RELAXANTS	0.81	-1.44
	SEDATIVE_HYPNOTICS	1.14	0.89
	SKIN_PREPS	1.21	1.33
Physical Exam	Age In Years	1.15	0.99
	Baseline Blood Pressure Diastolic	1.23	1.43
	Baseline Blood Pressure Systolic	0.83	-1.28
	BMI max	1.23	1.41
	BP Systolic mean	0.94	-0.39
	Heart Rate max	1.08	0.54
	Heart Rate min	1.11	0.69
	Heart Rate var	0.95	-0.35
	Physical Exam Resp Rate	1.10	0.64
	Physical Exam Temperature	0.92	-0.55
	pitting edema*	1.28	1.72
	Race African American	1.16	1.04
	Respiratory Rate max	0.91	-0.64
	SaO2	0.97	-0.20
	SPO2 min	0.84	-1.18
	Temperature max	0.98	-0.11
Test - Lab	Albumin max	0.89	-0.84
	Creatinine var	1.23	1.41
	HbA1c last is below 5.7	0.85	-1.12
	Hematocrit var	0.89	-0.83
	No INR Test	0.80	-1.53
	INR variance	0.92	-0.60
	PlateletCount last is b/w 150-449.99 K/uL	0.90	-0.71
	PlateletCount var	0.72	-2.22
	Potassium last is b/w 3.5-4.99 mmol/L	1.12	0.77
	Troponin var	0.97	-0.23
	WBC var	0.92	-0.61
Test - Image	LVEF min is below 50	2.04	4.92
	No LVEF Test	0.57	-3.84
Test - ECG	Atrioventricular and left bundle-branch block	1.24	1.45

ML Quick Review – Evaluation Metrics

Area Under the Receiver Operating characteristic Curve (AUROC or AUC)



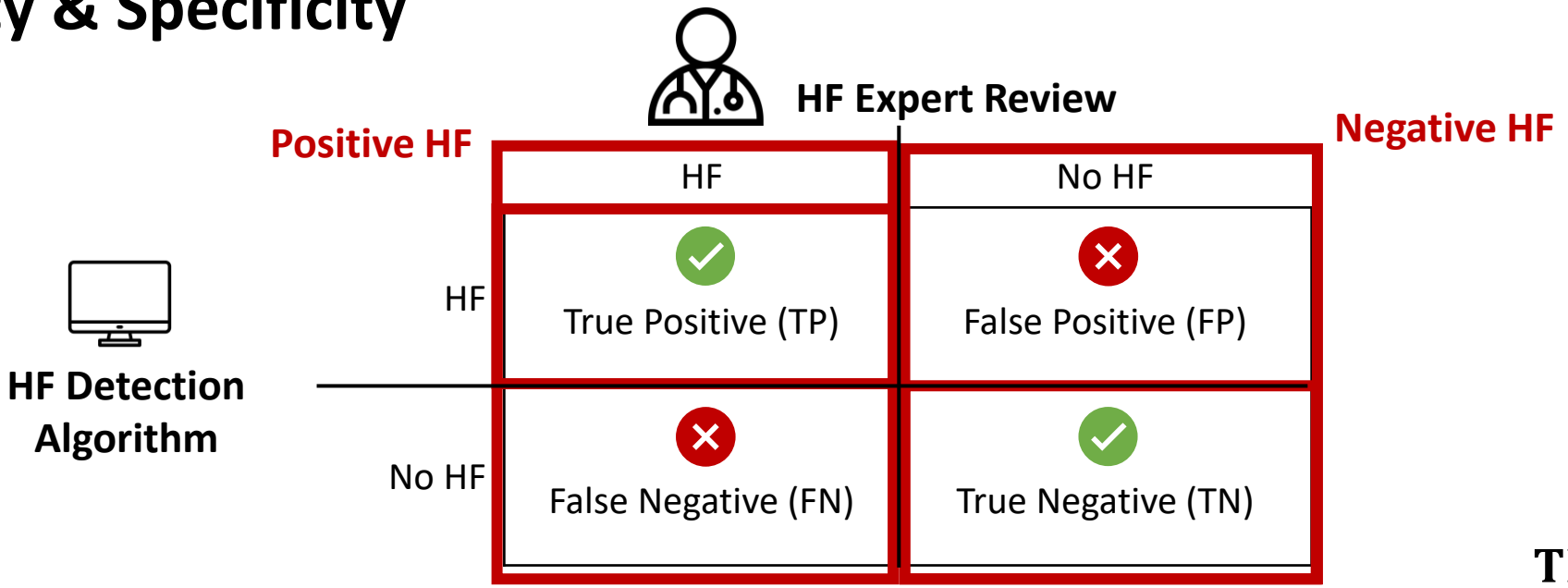
AUROC Values	Test Quality
1.00	Perfect test; 100% accurate
0.90	Better, Excellent
0.80	Good, Acceptable
0.70	Poor
0.50	No better than coin flip

$$\mathbf{TPR} = \text{Sensitivity}$$

$$\mathbf{FPR} = 1 - \text{Specificity}$$

ML Quick Review – Evaluation Metrics

Sensitivity & Specificity



$$\textbf{Sensitivity} = \frac{TP}{TP + FN}$$

The ability of HF algorithm to correctly detect patients **with** HF.

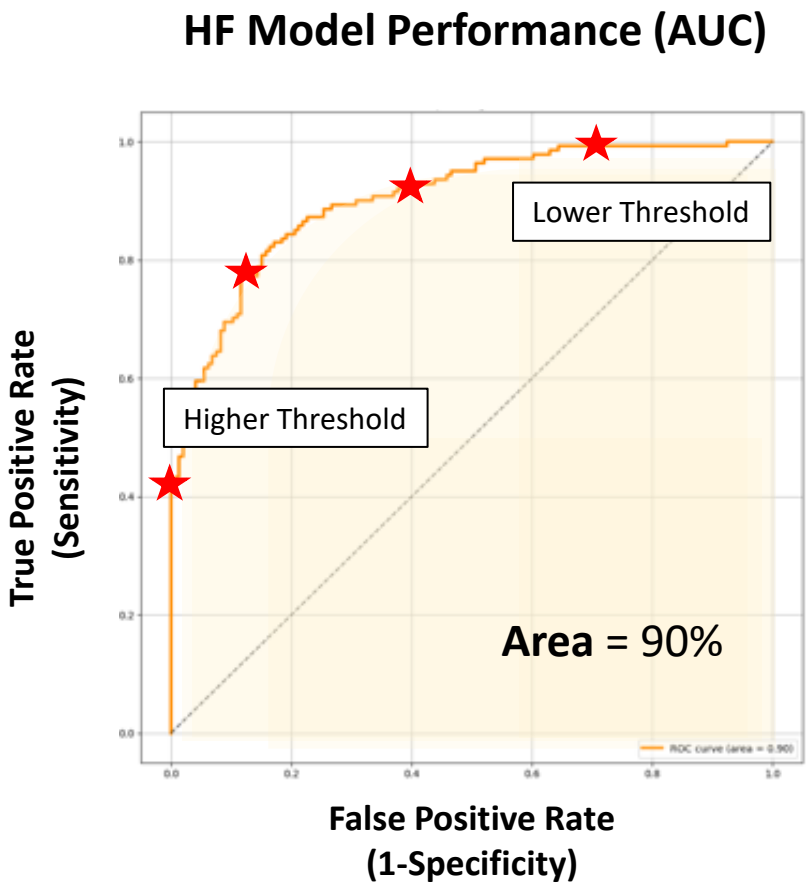
$$\textbf{Specificity} = \frac{TN}{FP + TN}$$

The ability of HF algorithm correctly detect patients **without** HF.

$$\textbf{TPR} = \text{Sensitivity}$$

$$\textbf{FPR} = 1 - \text{Specificity}$$

Interpretation of AUC

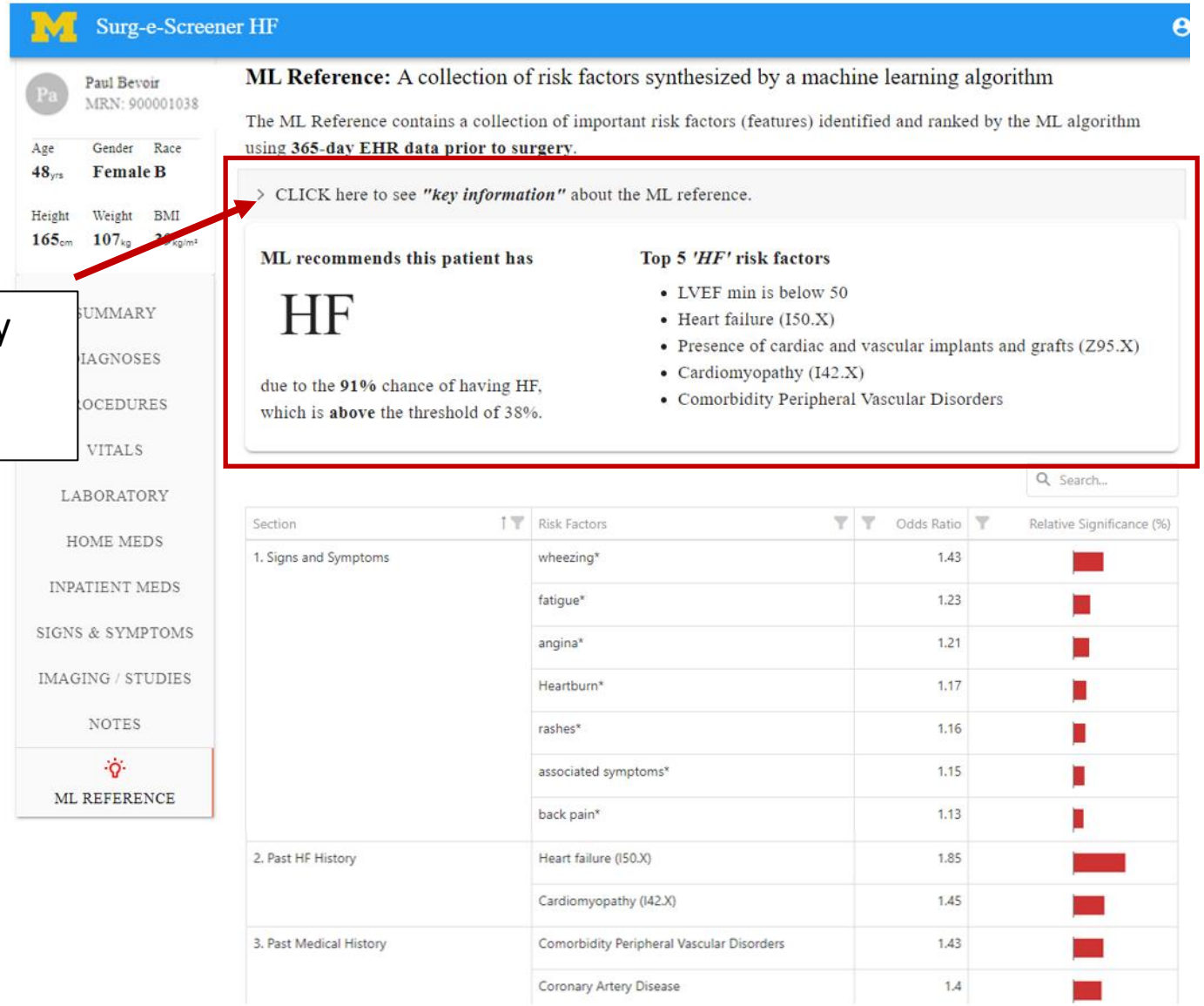


- **AUC** is a curve that plots TPR against FPR at various thresholds.
- **Threshold** is a cut-off probability to discriminate *HF* from *No HF,* a probability between 0 – 1 estimated by the HF model.
- **Lower** vs. **High** threshold
  - low threshold => most HF cases will be detected, but also high false positive cases. (high TPR and FPR)
  - high threshold => missing HF cases, but also low false positive cases will be detected (low TPR and FPR)

Tip: A higher threshold as TPR and FPR toward the origin (0, 0) in the AUC plot

Step 3. Machine Learning (ML) Reference

Click Tab to see key information about the ML reference



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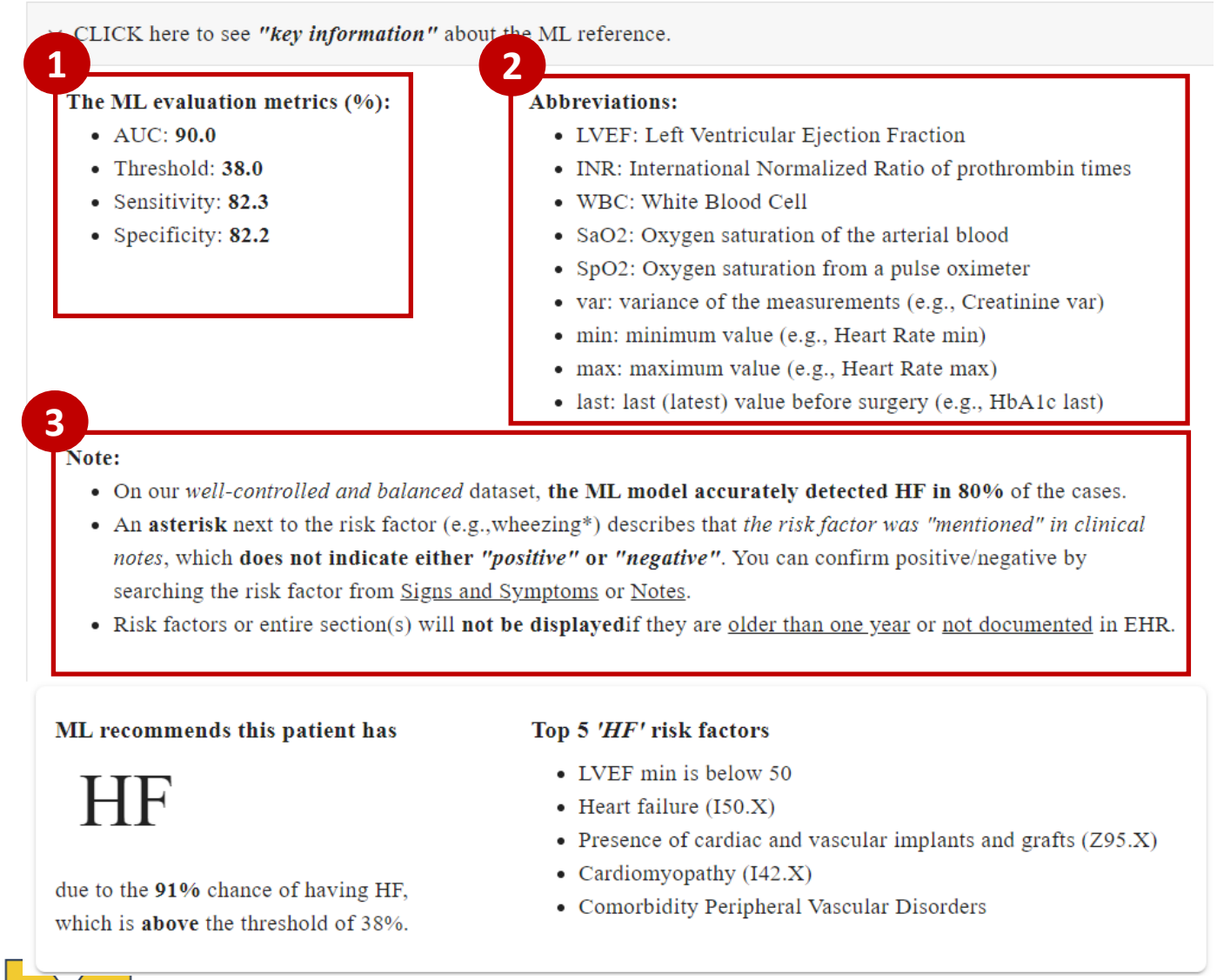


Key components

1. ML Reference Performance
2. Abbreviations
3. Notes:
   - This ML model achieved > 80% correct HF and No HF detection.
   - Risk factors with *
   - The model was trained on one-year EHR data

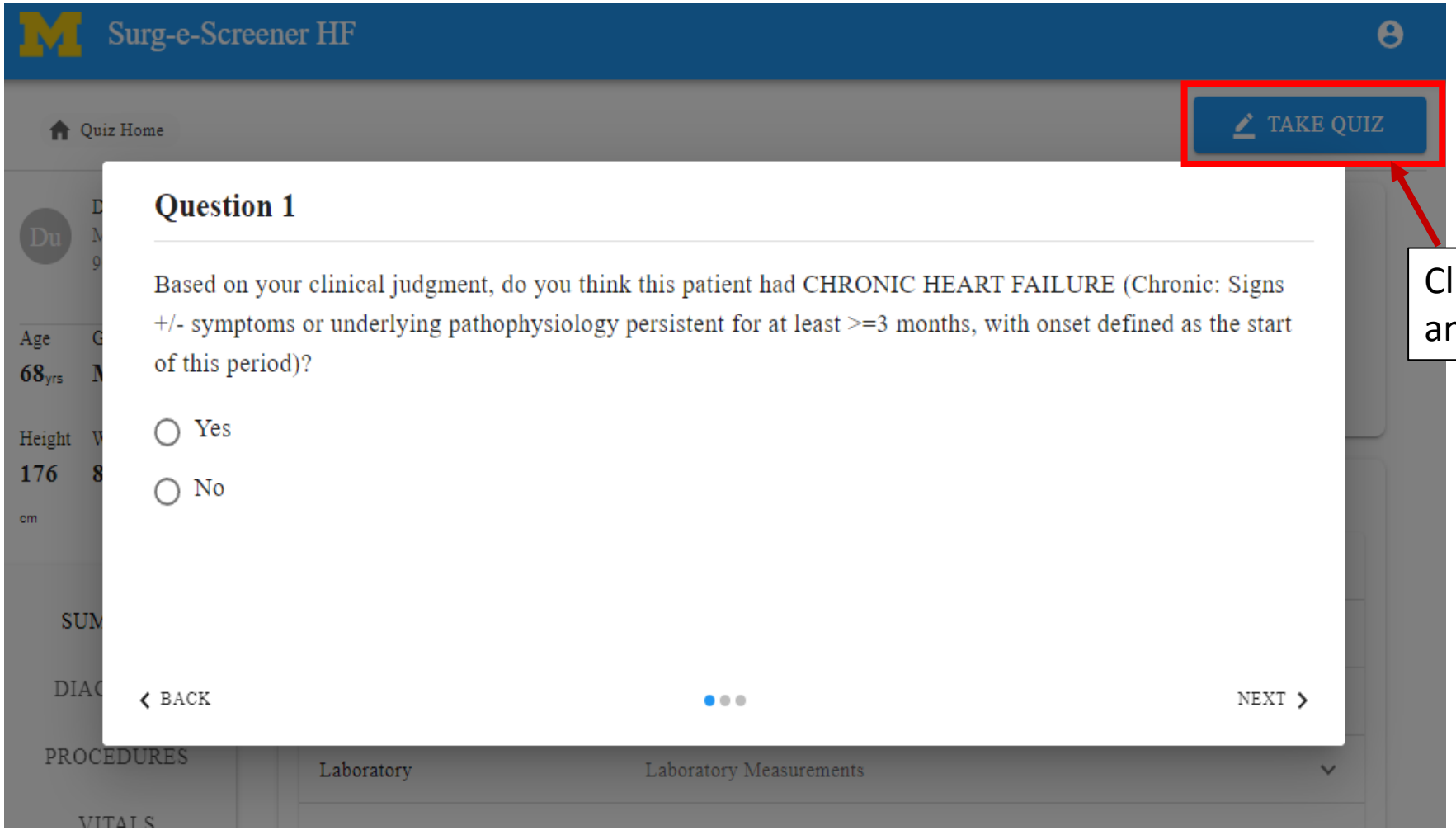
Data & ML Performance

- The ML model was trained and validated on a *well-controlled and balanced dataset*.
  - **Well-controlled**:
    - Adult patients >= 40 years old who had non-cardiac and non-emergent surgical procedures at MM.
    - >1,000 surgical cases *manually* reviewed by at least two HF experts per case
  - **Balanced**:
    - While the prevalence of HF is 2%, we trained the model on a reasonably balanced dataset of patients with and without HF.
    - This dataset includes a balanced mix of simple and difficult surgical cases for HF detection.

- The model performance:
  - AUROC = **90%**,
  - Threshold = **38%** (The best threshold to maximize TPR, while minimizing FPR)
  - Sensitivity = **82%** (TPR = Sensitivity)
  - Specificity = **82%** (FPR = **28%**, 1 – Specificity)

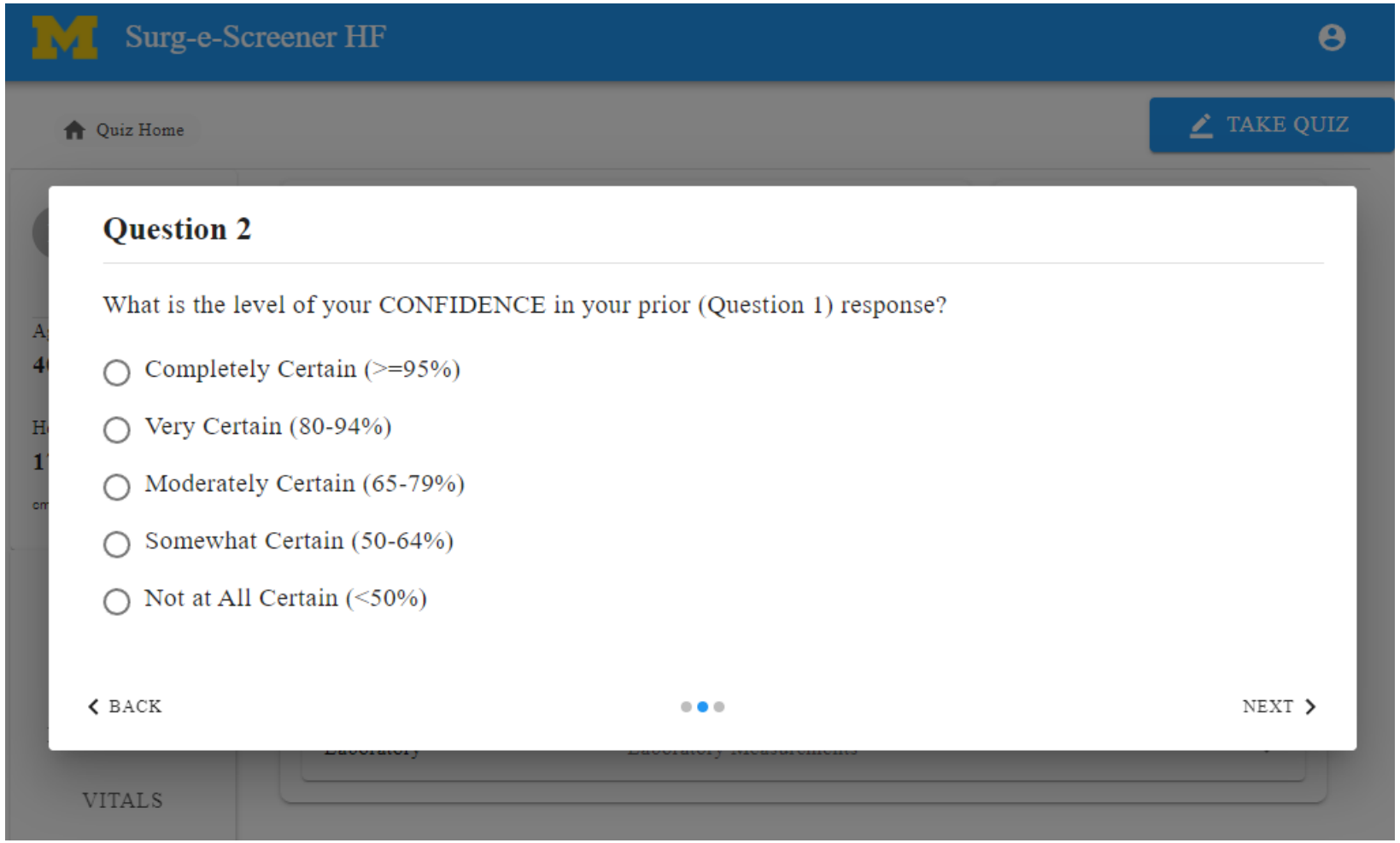
** This model **correctly** identified HF in **> 80%** of our dataset.

Step 4. *Post-test*: HF Recognition Quiz

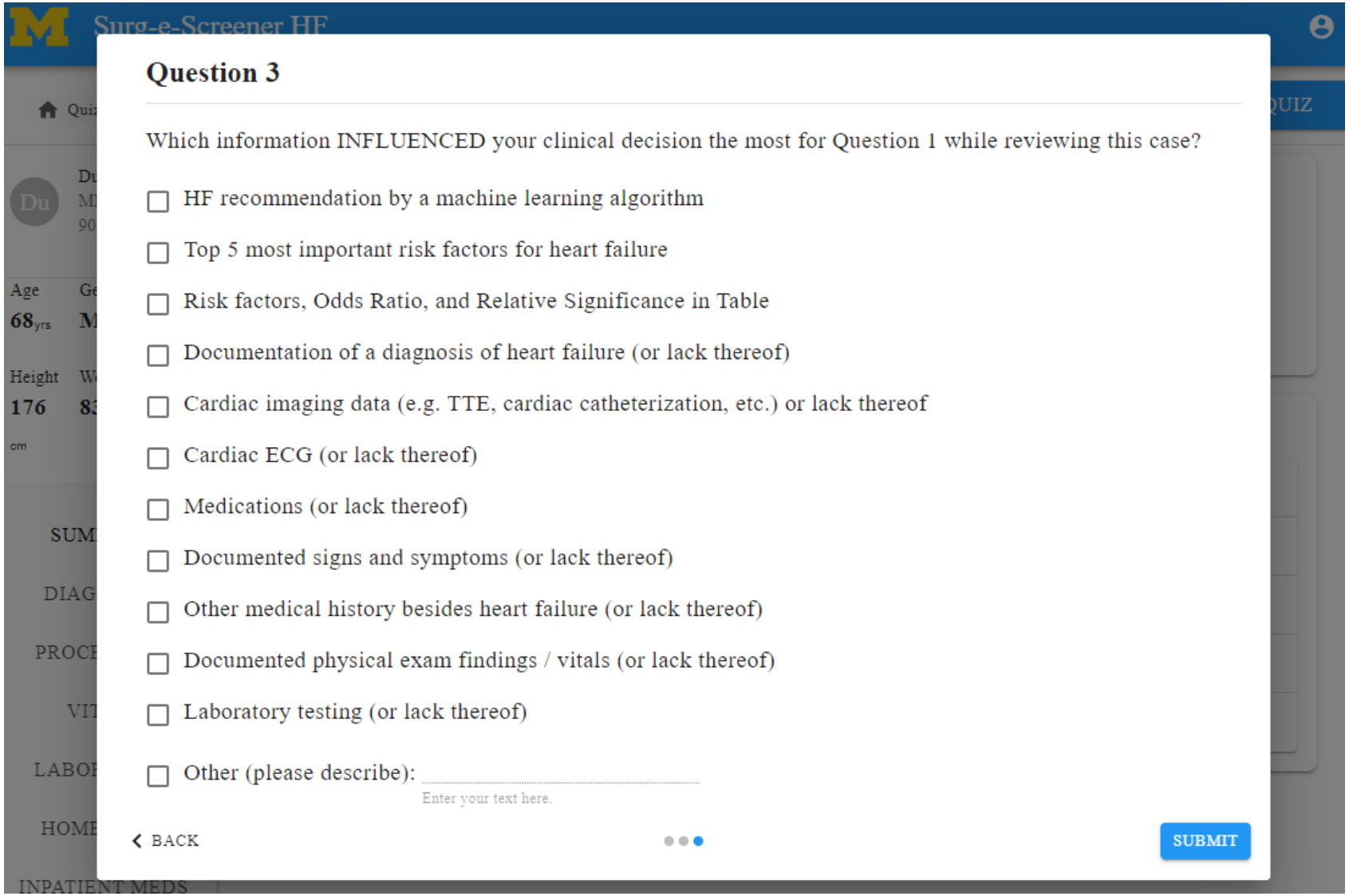


Click “Take Quiz” to answer your decision

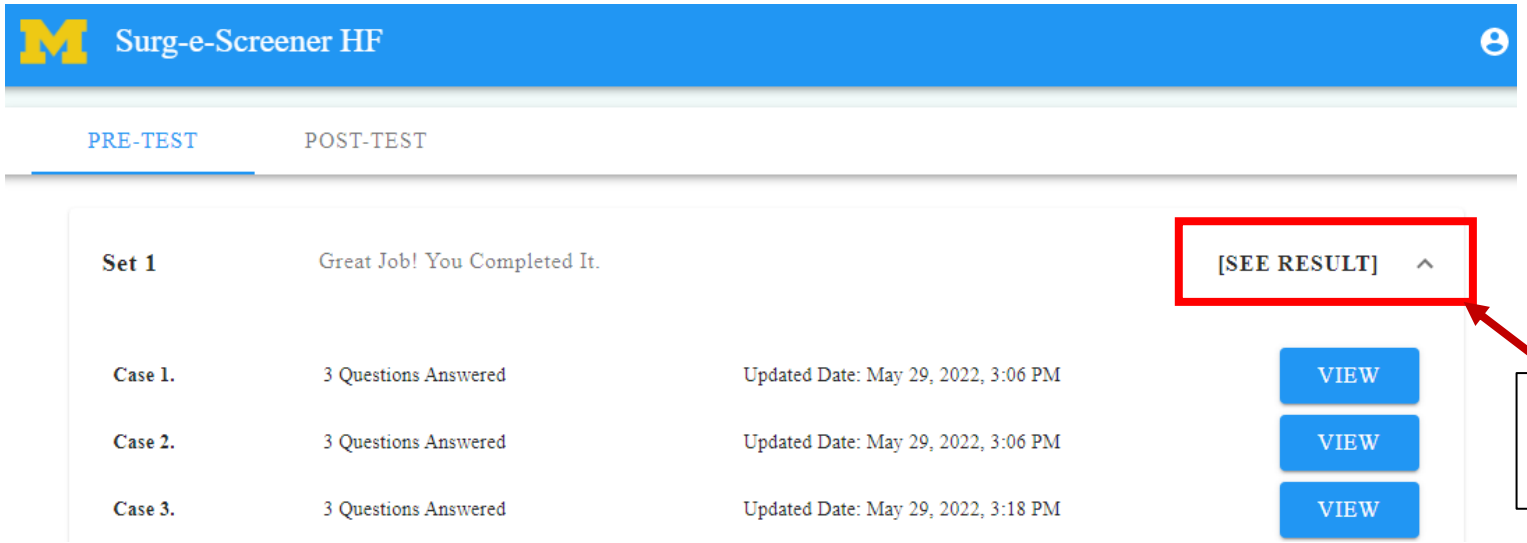
Step 4. *Post-test*: HF Recognition Quiz



Step 4. *Post-test*: HF Recognition Quiz



Step 5. Result Report Access

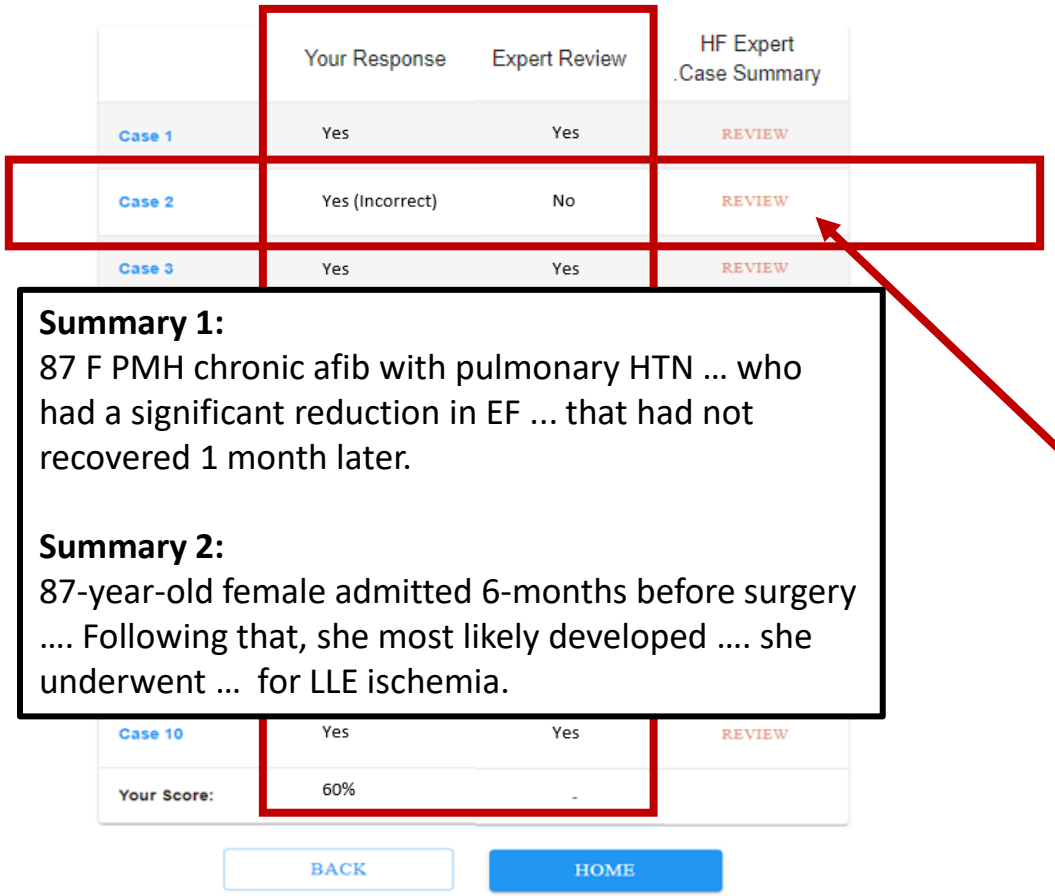


Click “SEE RESULT” to access the report

Key components

- SEE RESULT will be available after reviewing 20 surgical cases, 10 case review results in PRE-TEST and 10 case review results in POST-TEST.

Step 5. Expert Review Comparison



Review your result report

- **Compare your HF recognition** with the pre-determined answers by HF experts in each case.
- **Re-examine cases** when you are misaligned with the answers.
- Review **a short description** of the surgical cases summarized by the HF experts.

Summary of e-Learning Module

After watching this e-Learning module, you should be able to:

1. Understand the **process and activities required** to complete the HF recognition study
2. Interpret evaluation metrics such as **AUC**, **True Positive Rate (Sensitivity)**, and **False Positive Rate (1-Specificity)**
3. Describe how **TPR and FPR change** as the threshold increases or decreases

The short quiz will ask you mainly about Point 2 and Point 3.

Demo

Final Step

- No further actions after completing the test cases. We appreciate your participation.

- Reimbursement:
  - **Follow-up** if any case reviews remain **incomplete**
  - Pending follow-up / completion of all cases, you will receive reimbursement of **$50 as a check** delivered to your mailing address

- Email Hyeon Joo (thejoo@med.umich.edu) if any questions