StrokeClassifier:

An AI-Powered Ischemic Stroke Etiology Classification Tool to Reduce Recurrent Strokes

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funded by the Blavatnik Accelerator award

Preventing a recurrent stroke is critical for patient outcomes

- **~700,000** ischemic strokes/year in the US
- **1 in 4 patients have recurrent stroke** leading to disability, recurrent hospitalization, death

Stroke Etiology	Phenotypes	Proven Therapy	Stroke Risk Reduction
Large artery atherosclerosis (23%)	Carotid stenosis	Carotid artery revascularization	17%
	Intracranial stenosis	Dual antiplatelet therapy	34%
Cardioembolic (22%)	Atrial fibrillation	Anticoagulation	44%
	Endocarditis	Antibiotics	65%
Other determined (3%)	Patent foramen ovale	PFO Closure	77%
Small vessel disease (22%)	Small vessel disease	Dual antiplatelet therapy	32%

Recurrent stroke prevention hinges on **diagnosing the stroke etiology**
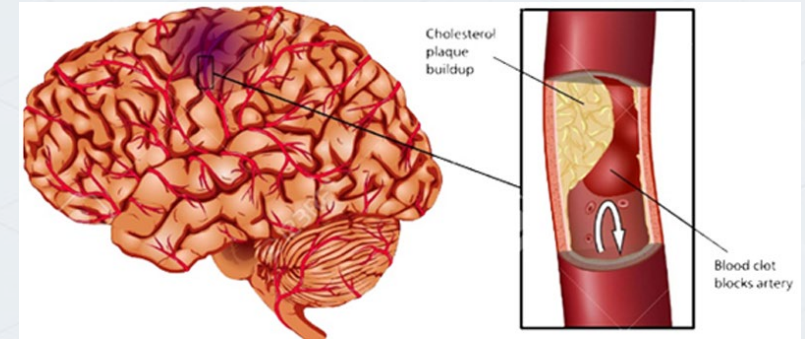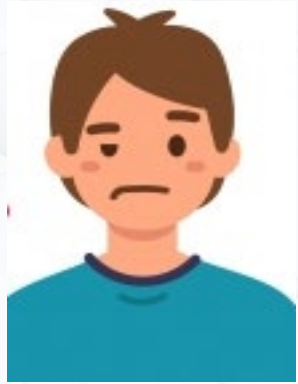

Challenge: Accurate and timely stroke etiology diagnosis to deliver therapies
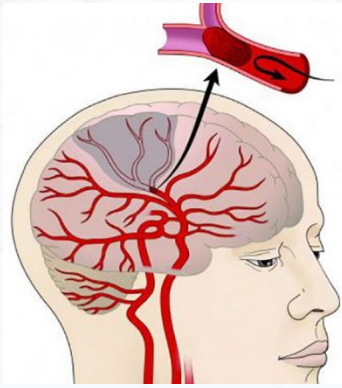
Treatments are underused!

The challenge of preventing recurrent strokes is ensuring timely and effective use of treatments, which are currently underutilized due to complex intervention pathways.

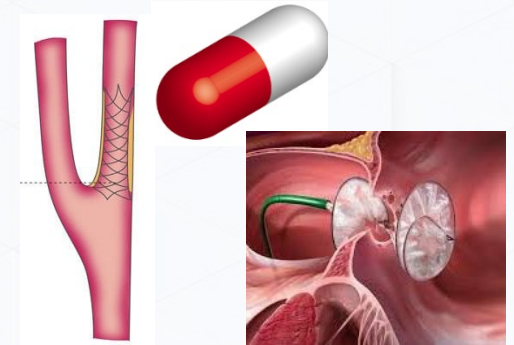# Current Stroke Etiology Diagnosis Workflow

Stroke Symptom Onset

Therapy Provided To Abort Stroke

Clinicians manually synthesize data to diagnose stroke etiology

Clinicians administer therapies proven to prevent stroke from diagnosed etiologies

The current diagnosis workflow **poses significant challenges**

Time-consuming: Up to 1 hour of clinician's time/patient

Shortage of expertise: Only 1/6 stroke patients treated by board-certified vascular neurologist

Diagnostic inaccuracy/uncertainty: human fallibility and cognitive biases; up to 30% cryptogenic

Re-hospitalizations for recurrent stroke: 14%
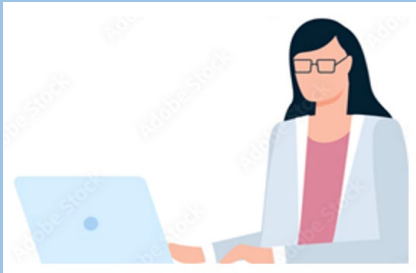
Our Solution:

StrokeClassifier

Our technology, ***StrokeClassifier***, is a computerized clinical decision support (CCDS) tool designed to fill this gap and equitably <u>elevate</u> the standard of care in the landscape of secondary stroke prevention.

Our Patent-Pending Solution: *StrokeClassifier* CCDS Tool

Electronic Health Record (EHR) Data

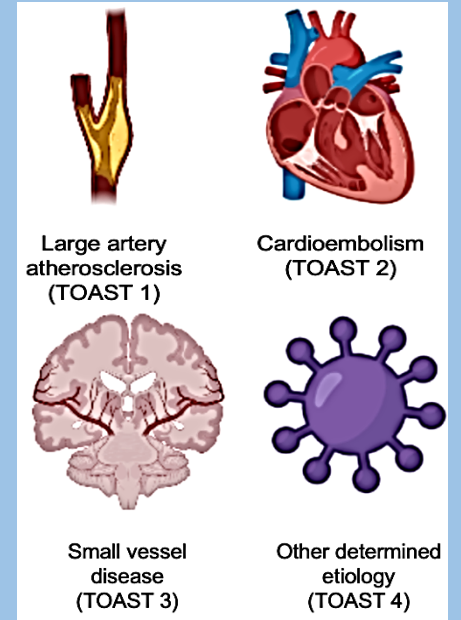## *StrokeClassifier* Algorithm*

EHR Data

StrokeClassifier: Ensemble Consensus Model

Etiology Prediction: Cryptogenic

Etiology Prediction: Non-Cryptogenic

Etiology Diagnosis

Large artery atherosclerosis (TOAST 1)

Cardioembolism (TOAST 2)

Small vessel disease (TOAST 3)

Other determined etiology (TOAST 4)

Integrating machine learning in stroke detection and prediction could greatly improve how quickly and effectively we prevent recurrence

StrokeClassifier Rivals Performance of Vascular Neurologists

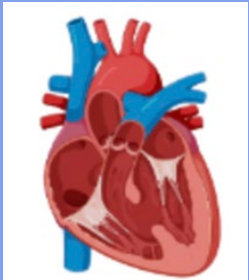| Stroke Etiology Diagnosis Agent	Accuracy of 4-Level Diagnosis Compared with Vascular Neurologists	External Validation in MIMIC-3	Diagnostic Time Per Patient
StrokeClassifier	~74% (AUCROC 90%)	~70% (AUCROC 81%)	<5 minutes (off the clock)
Non-vascular neurologists at YNHH	~56%	-	45-60 minutes
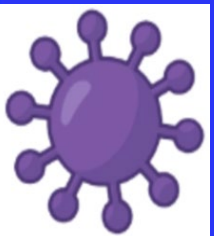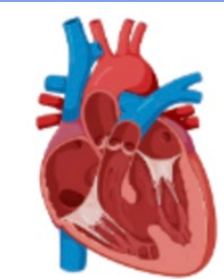
- **Customer Discovery Interviews**: 13/13 Clinicians Globally Caring for Stroke Patients
- **Benchmark** accuracy level desired to Adopt an AI Stroke Etiology Tool into Clinical Practice: <u>70%</u>

StrokeClassifier Accurately Predicts Individual Diagnoses

Etiology Diagnosis	Accuracy	False Positive Rate	False Negative Rate
Large artery atherosclerosis	84%	0.07	0.09
Cardioembolism	83%	0.10	0.07
Small vessel disease	91%	0.05	0.04
Other determined	91%	0.03	0.05

StrokeClassifier decreased the rate of cryptogenic stroke from **25% to 7%** (n=3,125)

StrokeClassifier can address the growing need for effective stroke prevention solutions

Total Addressable Market:

- 6,120 hospitals in the U.S. (96% use EHR)
- Hospitals worldwide using EHR

↑ Diagnostic capability comparable to stroke neurologists

↓ Diagnosis time: <5 min

Physicians

Hospitals
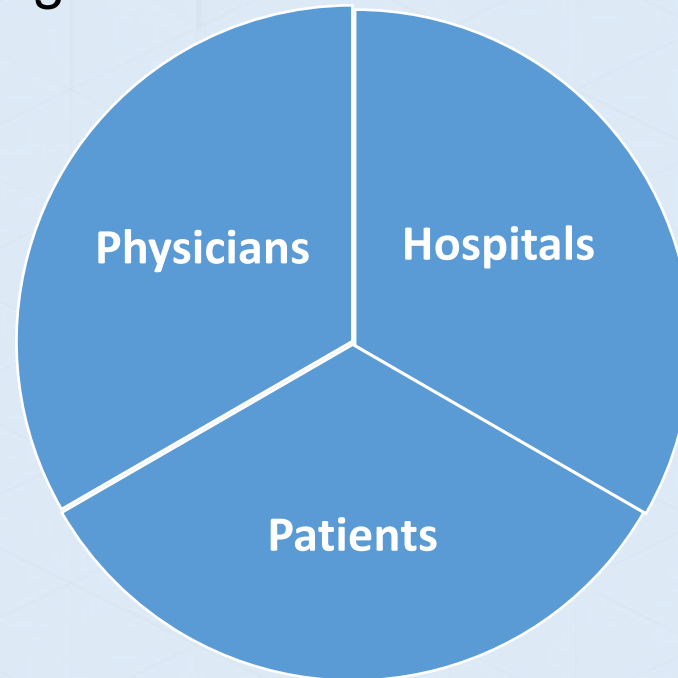
Patients

↑ Rates of appropriate diagnostics and therapeutics
↓ Readmission rates: ~$15,000

↓ Penalties incurred for readmission

↑ New technology Add-on Payments for use of AI-based software (upto $1,040/patient)

↓ Cryptogenic cases
↑ Prevention therapy implementation

Major Competitors

These help clinicians **abort** an acute, ongoing stroke.

AI Product in Stroke	Subscription Cost Per Hospital (per year)	Estimated Revenue (1/3*6120 hospitals)
RapidAI	$12,000	$24.5 million/year
Viz.AI	$25,000	$51 million/year
Aidoc	$30,000	$61.2 million/year
Brainomix	$29,000	$59.2 million/year

StrokeClassifier

- <u>Only</u> AI-based CCDS tool to **prevent** a stroke.

- Its diagnostic accuracy (74%), AUC (90%) and inference times (<5 minutes) are comparable to these FDA-approved solutions.

Performance of LVO and ASPECT Technologies

Legend: Viz LVO, RAPID, CINA, HALO, Rapid ASPECTS

Y-axis: Performance Metric (%); X-axis: AUC, PPV, NPV, Accuracy, Sensitivity, Specificity
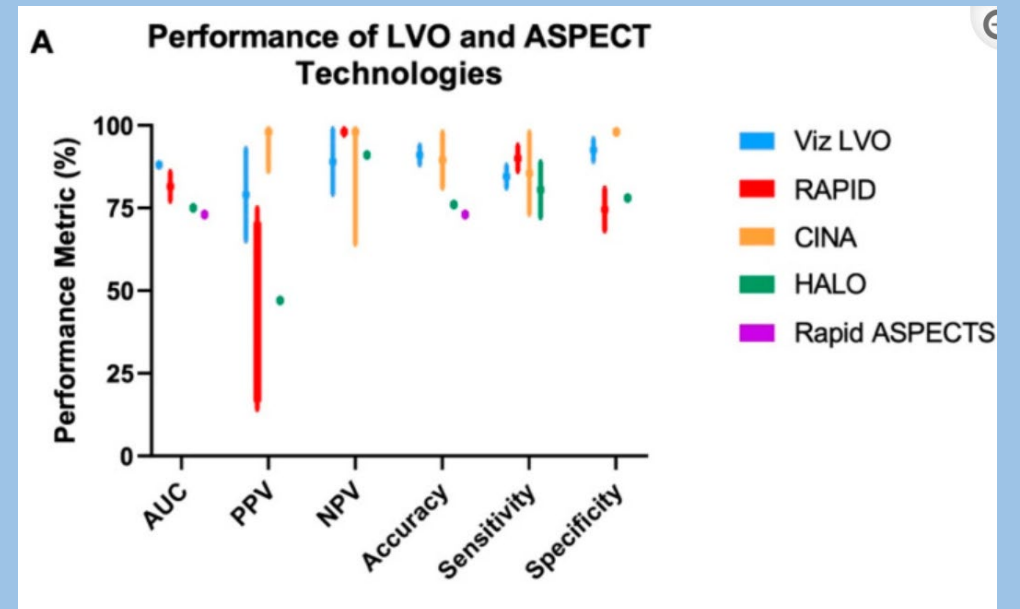
StrokeClassifier could become integral to health systems with partnership integration

StrokeClassifier

↓

Clinical utility ascertainment

↓

Further Development:
- Software Development
- FDA approval

↓

License acquisition

↓

American Heart Association

Hospital Systems

Blavatnik Accelerator

Blavatnik Funding

StrokeClassifier Recommendation Report		
Target	**Guideline-Recommended Therapy**	**Evidence**
Predicted Stroke Etiology		
Atrial fibrillation	Anticoagulation with DOAC	URL
Other Features		
LVEF 38%	Quadruple medical therapy for heart failure	URL
LDL 129 + statin allergy	PCSK9 inhibitor	URL
Hypertension	ACE inhibitor	URL
BMI 42	Mediterranean diet; nutrition referral	URL
Tobacco use	Nicotine replacement; Referral to smoking cessation program	URL
Tests Still Necessary		
Carotid ultrasound	-	URL
Stroke Prevention Clinical Trial Eligibility		
NCT_____		

Product Development Timeline & Funding

Our Ask: $150,000

- ❖ Software Development including Software Engineer and Computing needs($100,000) – develop UI / UX
- ❖ Commercialization Strategy ($35,000) – hire regulatory consultant to pursue an FDA application for a de novo Class 2 medical device designation
- ❖ Reimbursement Strategy and Payor Engagement ($15,000) – partner with a medical device reimbursement consultant

Phase 1: Algorithm Development (2021-2023)

- ➤ NIH/NINDS grant funding
- ➤ EHR data obtained from 2 Medical Centers
- ➤ Outcome adjudication by vascular neurologists
- ➤ 2000+ features engineered by NLP
- ➤ Development of *StrokeClassifier*
- ➤ External validation in the MIMIC-3 dataset Provisional patent obtained
- ➤ Manuscript accepted
- ➤ External validation in Veterans Health Administration system → *ongoing*
- ➤ NSF Northeast Regional I-Corps

Phase 2: Validation of Clinical Utility in 6 academic and community hospitals in YNHH network (2024-2025)

- ➤ Accuracy rate of diagnosis and abstracted stroke-related features
- ➤ Quantify missed opportunities by clinicians
- ➤ Value-of-information analysis
- ➤ Microsimulation analysis to ascertain added value/cost-savings

2021 **2022** **2023** **2024** **2025** **2026**

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***StrokeClassifier:* ischemic stroke etiology classification by ensemble consensus modeling using electronic health records**

Phase 3: Software Development, Acquiring Regulatory Approval, Commercialization (2024-2026)

- ➤ Develop UI/UX
- ➤ Pursue regulatory approval
- ➤ Develop reimbursement strategy
- ➤ Partner with American Heart Association to purchase an exclusive license for *StrokeClassifier*
- ➤ Resell into the market: Initial entry point- 20% hospitals in the AHA Get-with-the-guidelines Stroke Registry

Thank You

StrokeClassifier:

An AI-Powered Ischemic Stroke Etiology Classification Tool to Reduce Recurrent Strokes

Problem

Stroke care delays and specialist shortages drive high misdiagnosis and rehospitalization
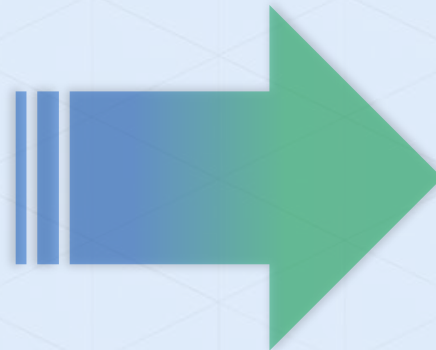
Solution

StrokeClassifier is a CCDS tool that utilizes AI to decrease misdiagnosis in recurrent stroke diagnosis

StrokeClassifier CCDS For An Individual Patient

StrokeClassifier Recommendation Report

Target	Guideline-Recommended Therapy	Evidence
Predicted Stroke Etiology		
Atrial fibrillation	Anticoagulation with DOAC	URL
Other Features		
LVEF 38%	Quadruple medical therapy for heart failure	URL
LDL 129 + statin allergy	PCSK9 inhibitor	URL
Hypertension	ACE inhibitor	URL
BMI 42	Mediterranean diet; nutrition referral	URL
Tobacco use	Nicotine replacement; Referral to smoking cessation program	URL
Tests Still Necessary		
Carotid ultrasound	-	URL
Stroke Prevention Clinical Trial Eligibility		
NCT_____		

Product Development Timeline

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- NIH/NINDS grant funding - EHR data obtained from 2 Medical Centers - Outcome adjudication by vascular neurologists 2000+ features engineered by NLP - Development of *StrokeClassifier* - External validation in the MIMIC-3 dataset Provisional patent obtained - Manuscript accepted - External validation in Veterans Health Administration system → *ongoing* - NSF Northeast Regional I-Corps	- Accuracy rate of diagnosis and abstracted stroke-related features - Quantify missed opportunities by clinicians - Value-of-information analysis - Microsimulation analysis to ascertain added value/cost-savings	- Partner with American Heart Association to purchase an exclusive license for *StrokeClassifier* - Develop UI/UX - Pursue regulatory approval - Resell into the market: Initial entry point- 20% hospitals in the AHA Get-with-the-guidelines Stroke Registry

**Phase 2 is an important step to prepare for this partnership.**

StrokeClassifier has the potential for to explore a variety of business models and market entries

	Direct-to-Healthcare Providers Model	Digital Health Platform Partnership	Data-as-a-Service (DaaS) Model
Description	License or sell the technology directly to hospitals, neurology clinics, and stroke rehabilitation centers	Partner with digital health platforms focused on chronic disease management to incorporate stroke prevention as a module	Offer the technology as a data analysis and insights service for stroke research institutions or pharmaceutical companies
Revenue Streams	• Subscription fees • Integration Costs • Pay-per-use	• Revenue-sharing • Per-user fees • Platform licensing	• Fee-for-service • Analytics subscription • Research partnerships
Pros	• Direct control over product deployment • High margins and predictable revenue	• Faster scalability through existing platforms • Lower upfront costs	• High demand for real-world data • Potential for high-profit margins
Cons	• Requires extensive sales and implementation support • Slower adoption due to long procurement cycles	• Limited control over end-user engagement • Potential for revenue dilution	• May require robust data privacy and compliance systems • Dependent on continuous data quality

Drivers of *StrokeClassifier* Predictions
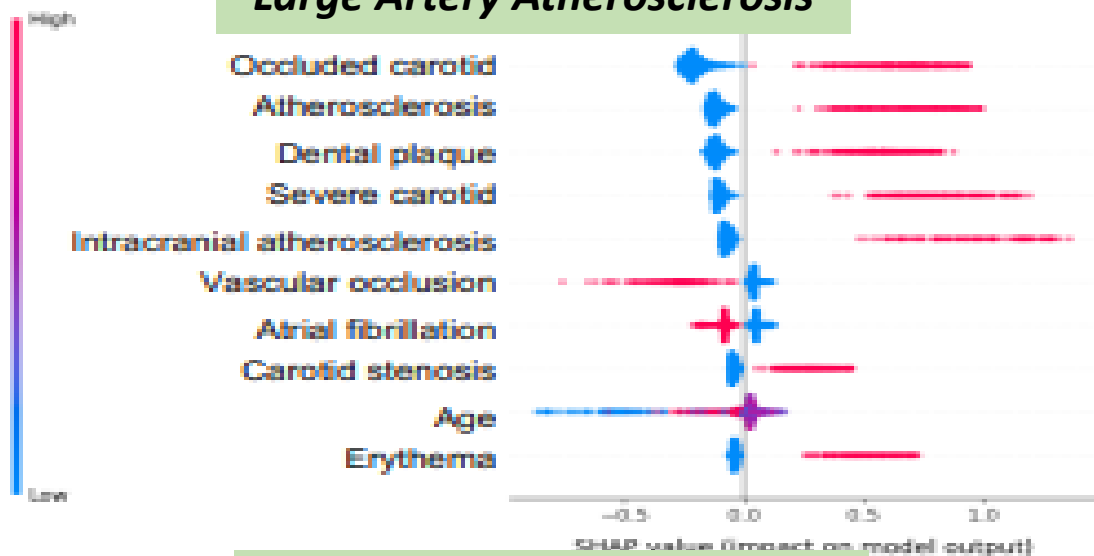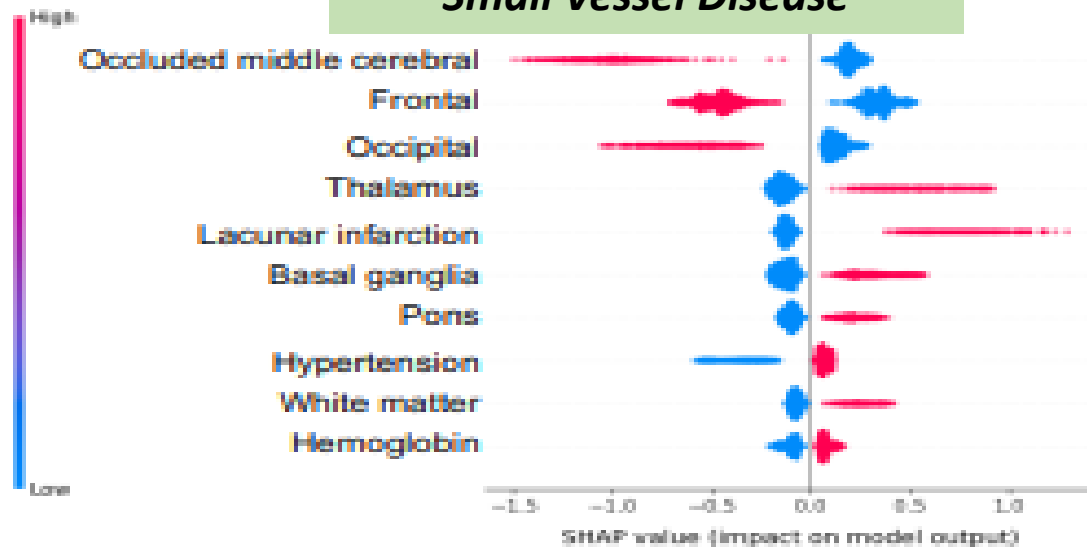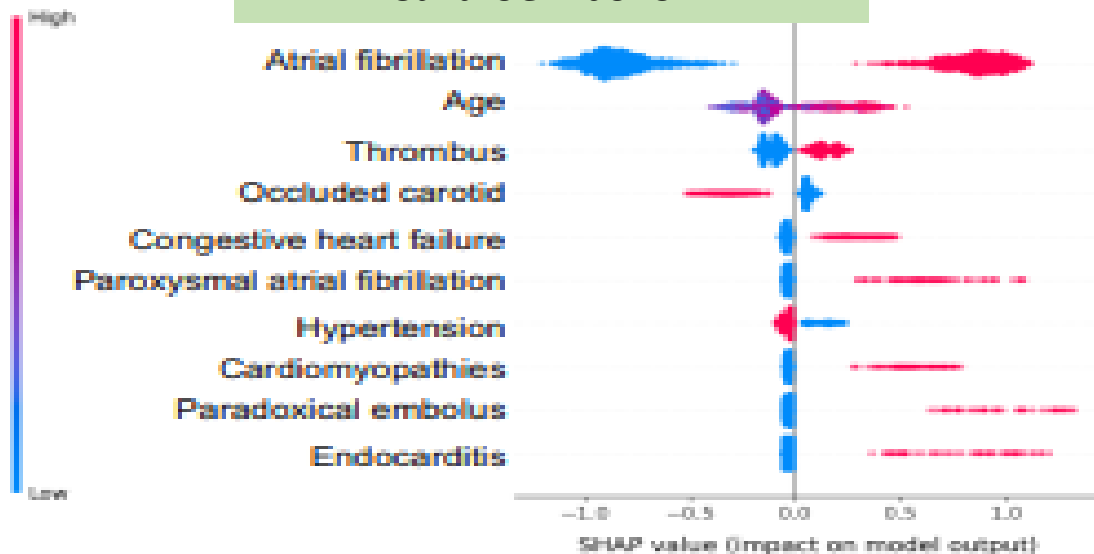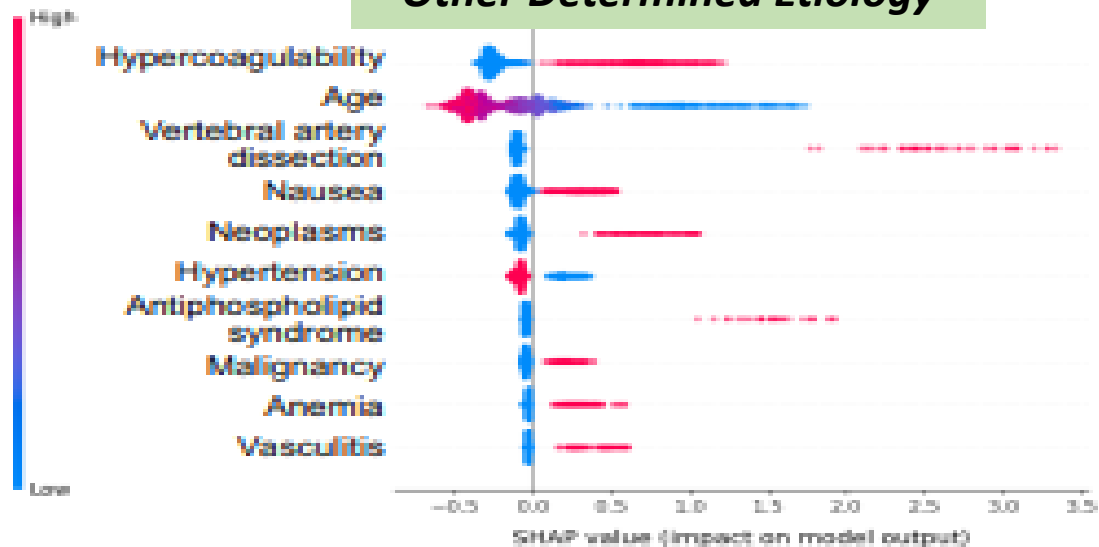
Quality Measures Fact Sheet

Hospital-Wide All-Cause Unplanned Readmission Measure (NQF #1789)

National Quality Strategy Domain: Communication and Care Coordination

Composite Quality Score

The Hospital-Wide All-Cause Unplanned Readmission measure is one component of the BPCI Advanced Composite Quality Score (CQS) calculation. The CMS Innovation Center uses the CQS to adjust a portion of any Positive Total Reconciliation Amount and any Negative Total Reconciliation Amount. The CQS adjustment will not adjust the Positive Total Reconciliation Amount down by more than 10 percent, nor will it adjust the Negative Total Reconciliation Amount up by more than 10 percent. More information is available at the BPCI Advanced website provided below.

Upto 10% negative reconciliation amount!

Your Clinical Decision Support Software: Is It a Device?

FDA

The FDA issued a guidance, Clinical Decision Support Software, to describe the FDA's regulatory approach to Clinical Decision Support (CDS) software functions. This graphic gives a general and summary overview of the guidance and is for illustrative purposes only. Consult the guidance for the complete discussion and examples. Other software functions that are not listed may also be device software functions. *

Your software function must meet all four criteria to be Non-Device CDS.

Summary interpretation of CDS criteria

1. Your software function does NOT acquire, process, or analyze medical images, signals, or patterns.

▶

2. Your software function displays, analyzes, or prints medical information normally communicated between health care professionals (HCPs).

▶

3. Your software function provides recommendations (information/options) to a HCP rather than provide a specific output or directive.

▶

4. Your software function provides the basis of the recommendations so that the HCP does not rely primarily on any recommendations to make a decision.

▶

Your software function may be non-device CDS.

Non-Device Examples

Non-Device examples display, analyze, or print the following examples of medical information, which must also not be images, signals, or patterns:

AND

Non-Device examples provide:

- Information whose relevance to a clinical decision is well understood
- A single discrete test result that is clinically meaningful
- Report from imaging study

- Lists of preventive, diagnostic, or treatment options
- Clinical guidelines matched to patient-specific medical info
- Relevant reference information about a disease or condition

AND

Non-Device examples provide:

- Plain language descriptions of the software purpose, medical input, underlying algorithm
- Relevant patient-specific information and other knowns/unknowns for consideration

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Device Examples

Device examples acquire, process, or analyze:

- Signal acquisition systems
- In vitro diagnostics
- Magnetic resonance imaging (MRI)
- Next Generation Sequencing (NGS)
- Continuous Glucose Monitoring (CGM)
- Computer aided detection/diagnosis (CADe/CADx)

OR

Device examples display, analyze or print:

- Continuous signals/patterns
- Medical images
- Waveforms (ECG)
- More continuous sampling (aka – a signal or pattern)

OR

Device examples provide:

- Risk scores for disease or condition
- Probability of disease or condition
- Time-critical outputs

OR

Device examples:

- Basis of recommendations is not provided

Your software function is a device.

Breakthrough Device Designation

Criteria	Description	Refer to Guidance
First Criterion	The device provides for more effective treatment or diagnosis of life-threatening or irreversibly debilitating human disease or conditions	Section III.B.1
Second Criterion	The device also meets **at least one** of the following:	
	a. Represents Breakthrough Technology	Section III.B.2.a
	b. No Approved or Cleared Alternatives Exist	Section III.B.2.b
	c. Offers Significant Advantages over Existing Approved or Cleared Alternatives	Section III.B.2.c
	d. Device Availability is in the Best Interest of Patients	Section III.B.2.d