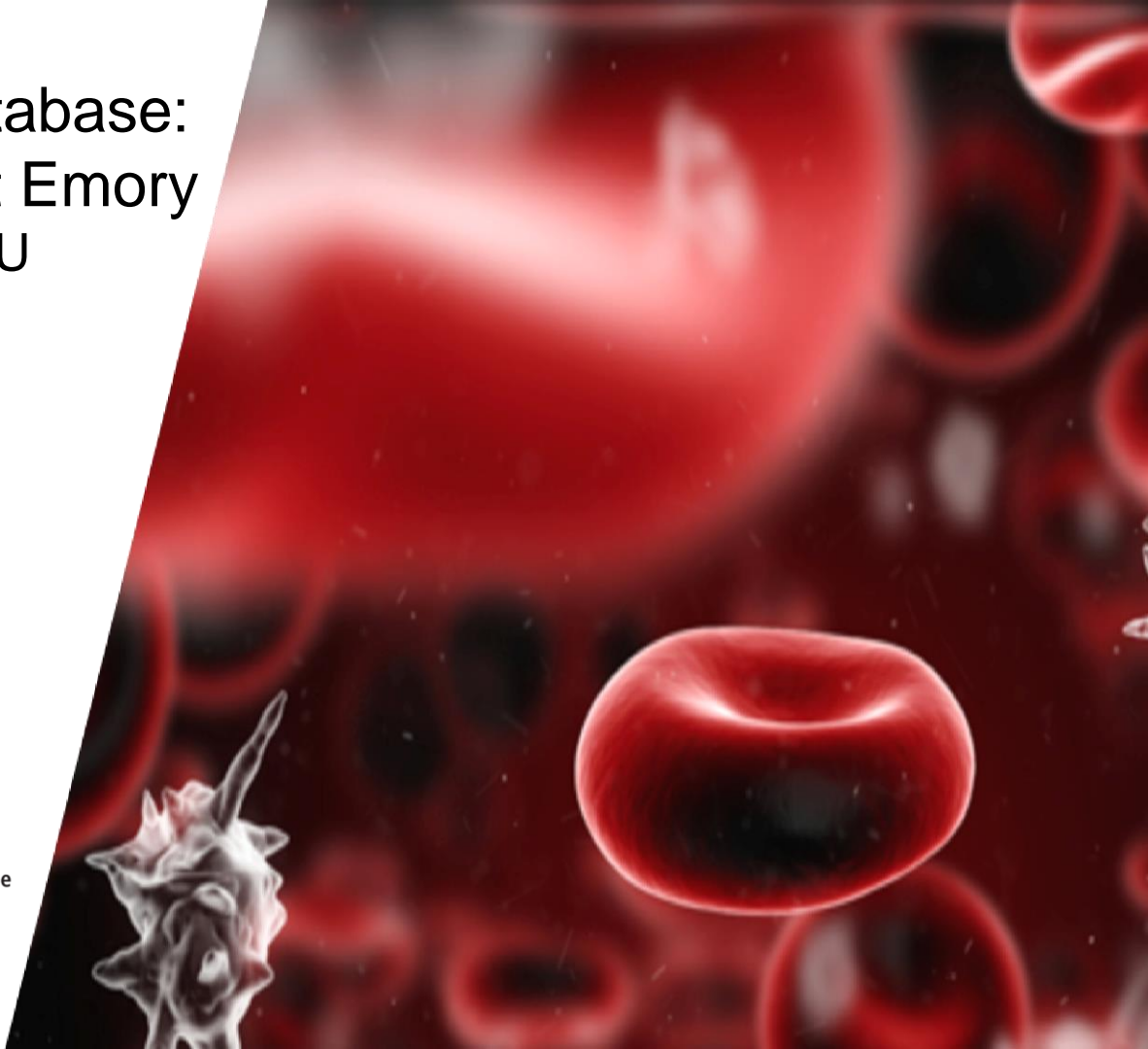


Leveraging the eICU database: Streaming Informatics at Emory Prediction of Sepsis in the ICU



EMORY
UNIVERSITY

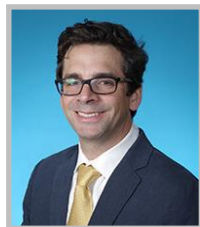
**Department of
Biomedical Informatics**
Emory University School of Medicine



The team



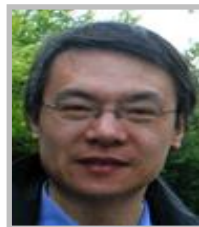
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Director
Emory Critical Care Center



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Assistant Professor
Biomedical Informatics



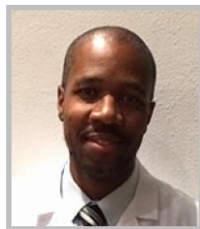
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Resident
School of Medicine



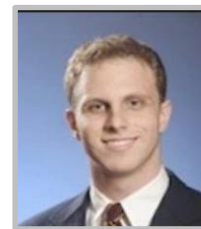
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Biomedical Informatics



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Deep Learning Expert
Georgia Tech



Benjamin Arar
Data Scientist
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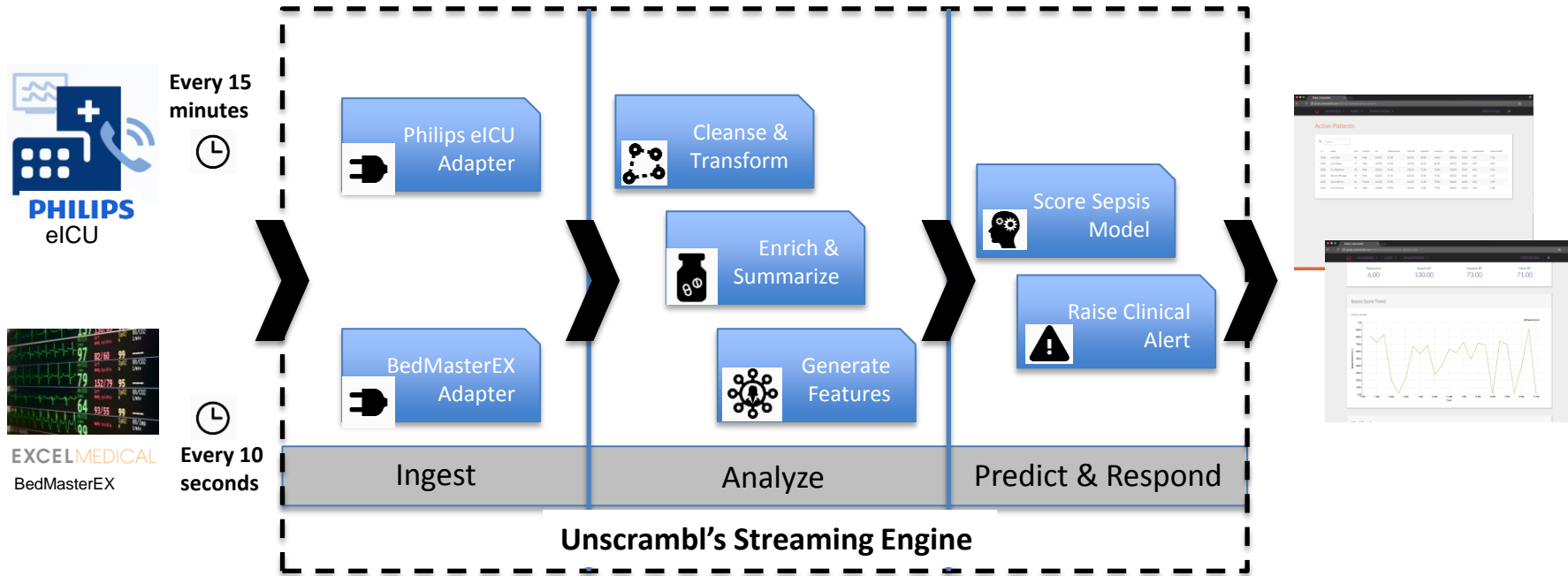


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The data pipeline using Unscrambl Pulse



Presentation and notification at Emory

The screenshot displays a web application interface for a healthcare dashboard. At the top, there is a navigation bar with a logo on the left and menu items: 'DASHBOARDS', 'ALERTS', and 'ADMINISTRATION'. On the right side of the navigation bar, the user is identified as 'Administrator' with a profile icon. Below the navigation bar, the main content area is titled 'Active Patients' in orange text. Underneath this title is a search bar with a magnifying glass icon and the placeholder text 'Search'. The primary data is presented in a table with 15 columns: ID, NAME, AGE, GENDER, BEDSIDE, EMR, HR, TEMPERATURE, SYSTOLIC BP, MEAN BP, DIASTOLIC BP, SAO2, ETCO2, RESPIRATION, and SEPSIS SCORE. Each row represents a patient, with green circular indicators in the 'BEDSIDE' and 'EMR' columns. The table lists four patients: Bernard Morgan, Jane Doe, Josh Freeman, and Sara Warren, each with their respective vital signs and a sepsis score.

ID	NAME	AGE	GENDER	BEDSIDE	EMR	HR	TEMPERATURE	SYSTOLIC BP	MEAN BP	DIASTOLIC BP	SAO2	ETCO2	RESPIRATION	SEPSIS SCORE
89034dfb56c4c5a8c6953beaec4a26f	Bernard Morgan	79	Male	●	●	91.00	-	101.00	61.00	41.00	95.00	-	18.00	0.20
bac33e5db1d0f9ffe2091044e58a9394	Jane Doe	67	Female	●	●	108.00	-	165.00	91.00	68.50	99.00	28.00	20.50	0.44
4d46bc59629604b671e43c51385490cd	Josh Freeman	68	Male	●	●	90.00	-	-	-	-	99.00	-	23.00	0.20
9007636124fa4a42caa84fc025236386	Sara Warren	69	Female	●	●	101.00	-	167.00	105.00	79.00	97.00	26.00	32.00	0.36

The dashboards show a list of active patients

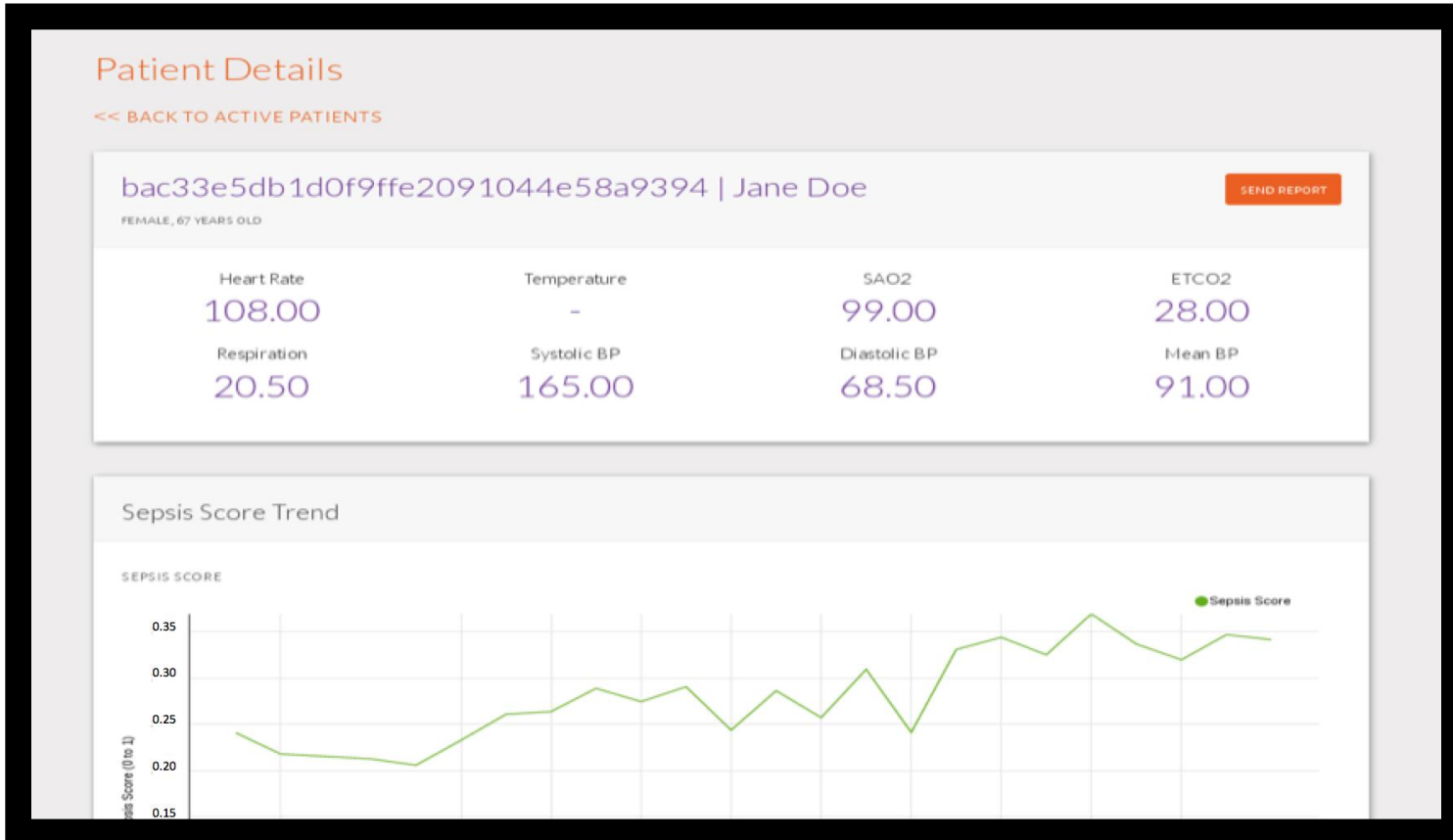
Presentation and notification at Emory

The screenshot displays a web-based dashboard for patient monitoring. At the top, there are navigation tabs for 'DASHBOARDS', 'ALERTS', and 'ADMINISTRATION', along with a user profile for 'Administrator'. The main heading is 'Active Patients'. Below this is a search bar and a table of patient data. A red notification box in the top right corner indicates a critical alert for a patient with a high sepsis score.

ID	NAME	AGE	GENDER	BEDSIDE	EMR	HR	TEMPERATURE	SYSTOLIC	MEAN BP	DIASTOLIC	SAO2	ETCO2	RESPIRATION	SEPSIS SCORE
89034dfb56c4c5a8c953beaec4a26f	Bernard Morgan	79	Male	●	●	91.00	-	101.00	62.00	44.00	96.00	-	22.00	0.16
ba33e5db1d0f9ffe2091044e58a9394	JaneDoe	67	Female	●	●	109.00	-	134.50	77.00	57.00	99.00	29.00	18.00	0.38
4d46bc59629604b671e43c51385490d0	Josh Freeman	68	Male	●	●	93.00	-	-	-	-	99.00	-	23.00	0.26
9007636124fa4a42caa84fc025236386	Sara Warren	69	Female	●	●	91.00	-	166.00	104.00	77.00	92.00	25.00	33.00	0.38

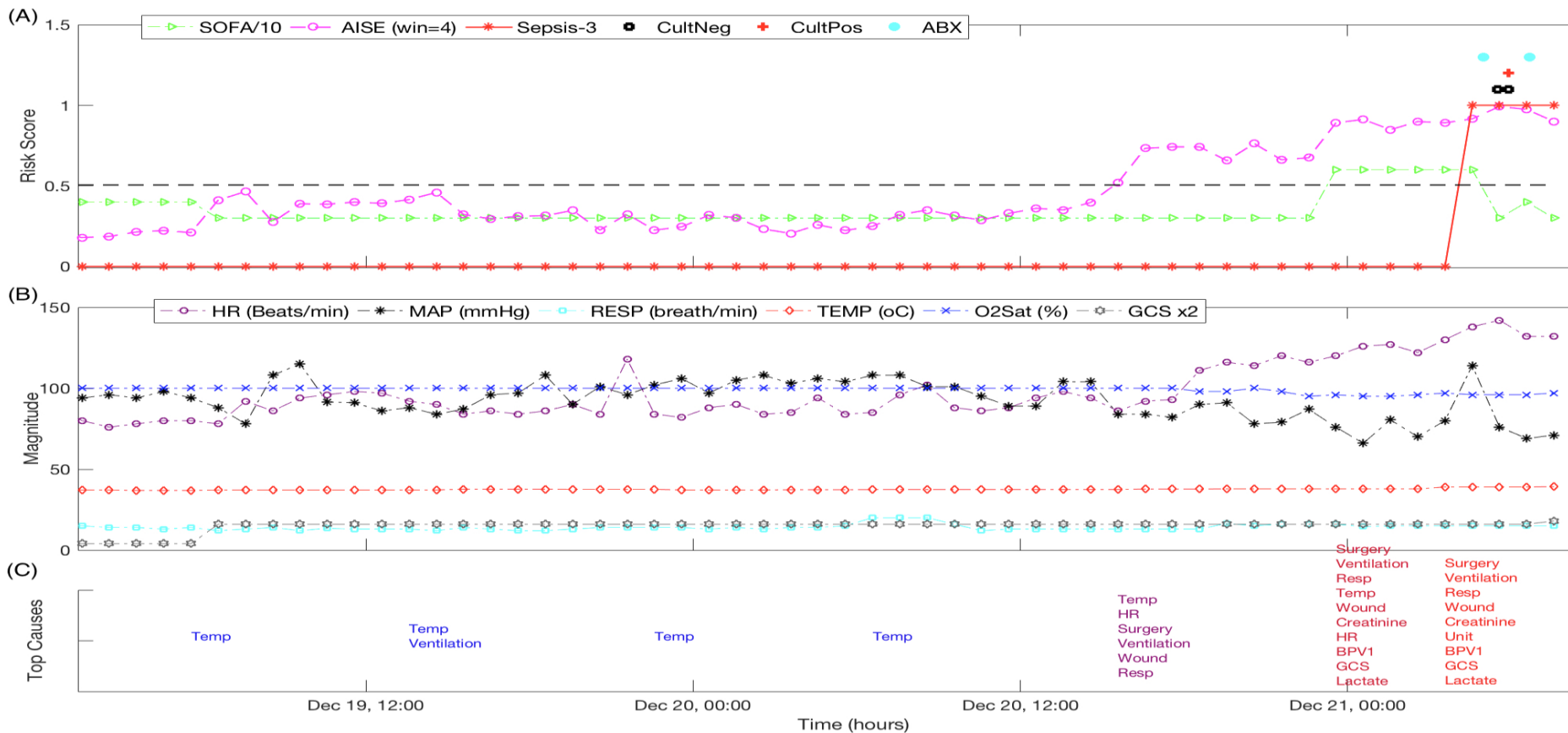
The system show up alerts for patients whose sepsis score breaches a threshold. More complex triggers can be created.

Presentation and notification at Emory



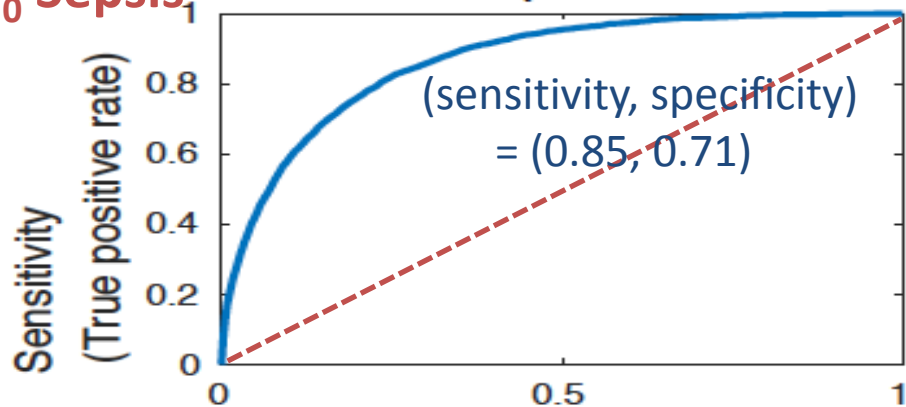
The patient details page show various vitals, sepsis score trend and other parameters. This could be emailed by clicking on the send report button.

Not a Blackbox: Interpretable Machine Learning for Early Prediction of Sepsis (Nemati et al. CCM, 2017)



T₀ Sepsis

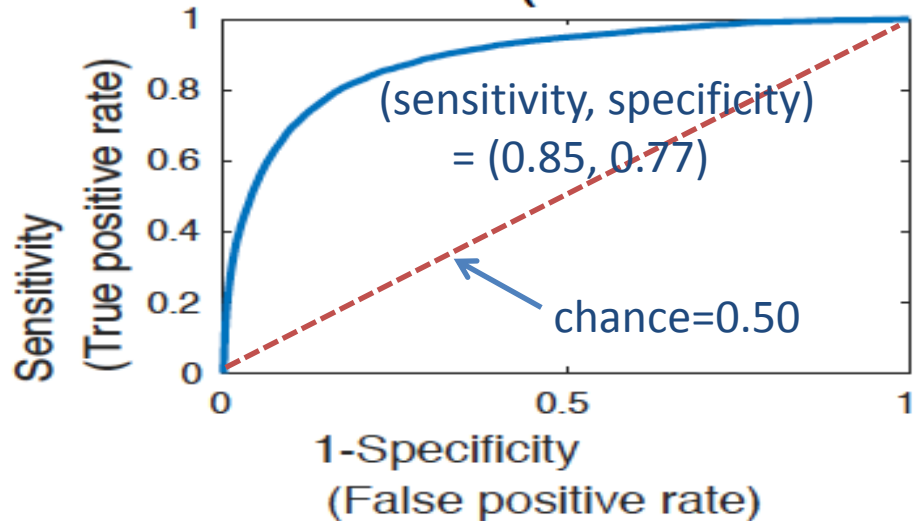
ROC curve (AUC=0.87)



- T₀-Sepsis: Prediction of clinical suspicion (sepsis-III)

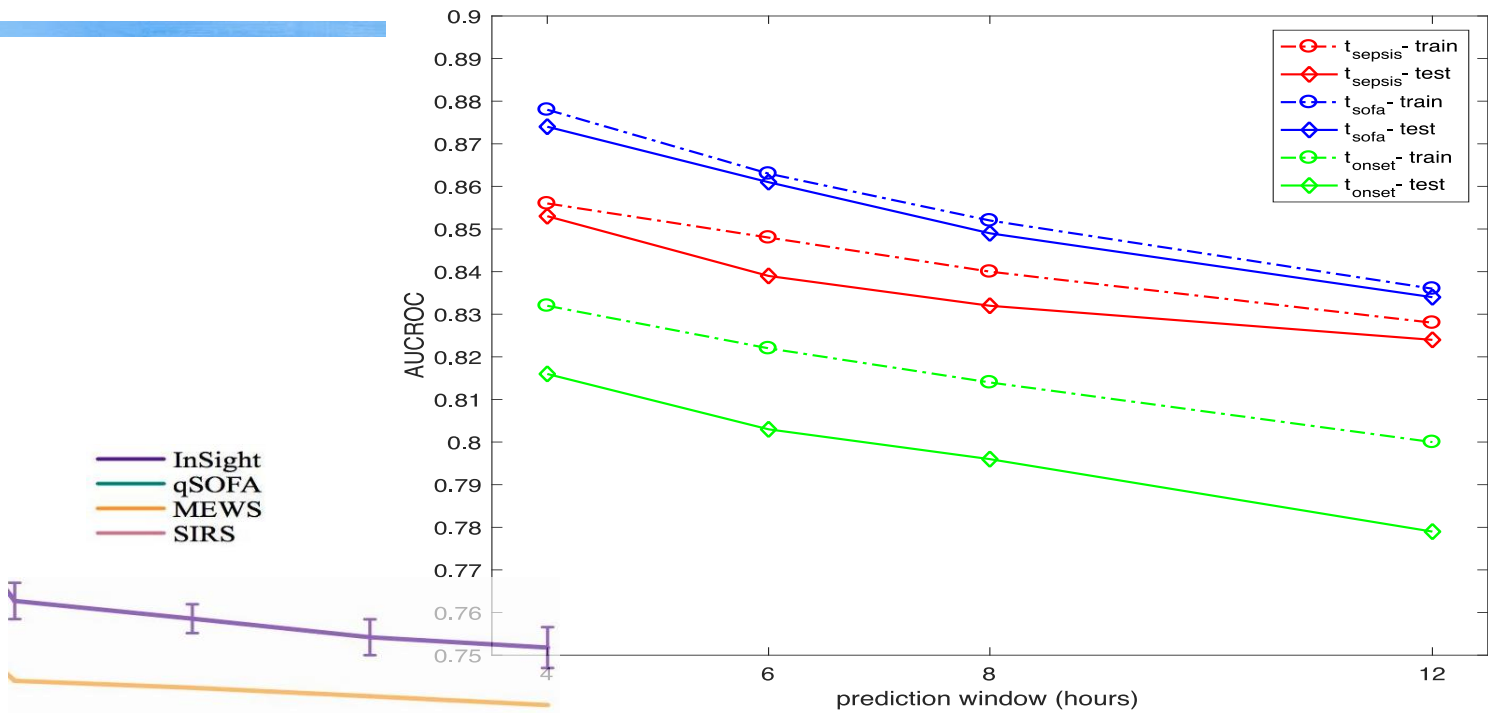
T₀ SOFA

ROC curve (AUC=0.89)



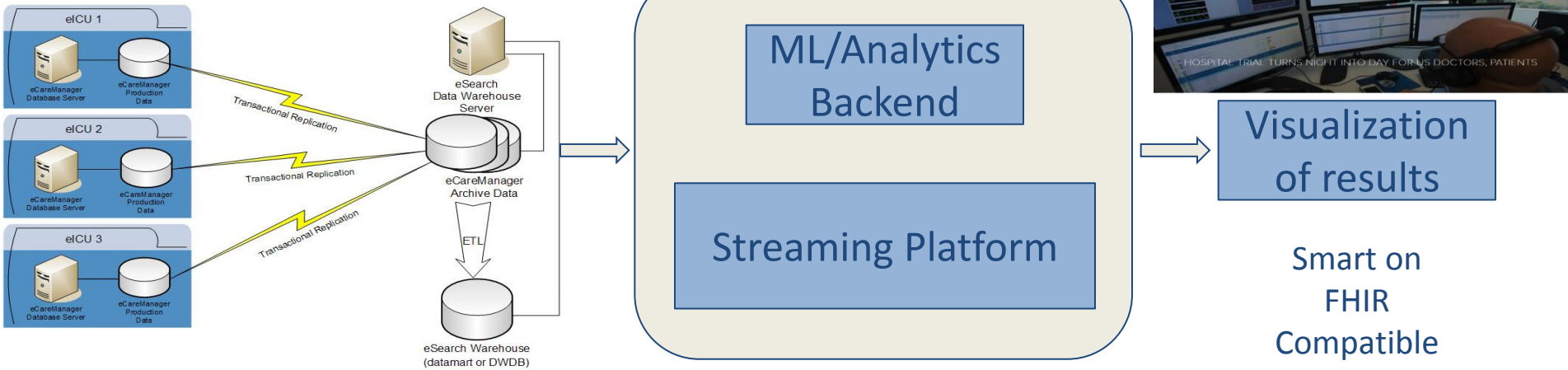
- T₀-SOFA: Prediction of organ dysfunction (Δ SOFA \geq 2)

How far in advance can we predict?



T_{sepsis} = sepsis 3 definition
 T_{sofa} = time of 2-point change in SOFA associated with the definition of sepsis.
 T_{onset} = minimum of T_{sepsis} and T_{sofa} , so the earlier time of when a clinician became suspicious (T_{sepsis}) or there was a change in physiology (T_{sofa})

Emory's eICU-BMI Platform for Real-time Analytics



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Road Map to Wider Implementation

- Retrospective Validation Studies
 - Emory Dataset (30K patients, 2 hospitals)
 - MIMIC III Database (~50K patients, Beth Israel Hospital)
 - Emory eICU Dataset (20K patients, 5 hospitals)
- Prospective Validation
 - Real-time implementation
- Clinical Trials
 - Stepped wedge trial design
 - Multi-center -> Clinical Evidence
- Impacting the *standard of care*
 - Surviving sepsis guidelines



Complex queries pulls data from the eICU ArchiveDB in real-time

The screenshot shows the Microsoft SQL Server Management Studio interface. The title bar indicates the connection to 'archiveDB' on server '163.246.238.109'. The query editor contains a complex SQL query with multiple joins and a list of lab item IDs. The results pane shows a table with 12 columns and 8 rows of data.

```
select top 3000 firstName, abgLabItem= valueName,abgLabValue=abgLab.labResultNumeric,abgLab.labItemNameID,vs.observationDate,heartRate,resp  
from abgLab  
inner join plValue as pl1 on pl1.valueID=abgLab.labItemNameID  
inner join vitalSignPeriodic5minute vs on vs.patientHealthSystemStayID=abgLab.patientHealthSystemStayID  
inner join chemistryLab as cl on cl.patientHealthSystemStayID=abgLab.patientHealthSystemStayID  
inner join patientHealthSystemStay hs on hs.patientHealthSystemStayID= abgLab.patientHealthSystemStayID  
inner join patient on patient.personID=hs.personID  
inner join person on person.personID=patient.personID  
where abgLab.labItemNameID in  
( '6888379d5fcd4cd8b8a4bddc73adb32c', 'b293f206fa9b4c8992679c34a4946d13', '8803942a916a4dd1a54963b469f9896e', 'd84cf4287f2d47acb6c91cb70330c  
and cl.labItemNameID in('53c08e0380dc489aac8f0e27ebb5006', 'ff57898da32d446ca81c96921dabf88c'  
, 'db9dd2caa28a478f866760da7edbb715'  
, '5525d84299454acd81539d11fcab796c', '6cb71776e24f420dabf66710c361f45a'  
, 'edf6ea27513f445ca0ae8289b08e4881', '3966f6c4fabf4bfe943624bf3642d782', '95ffh6bhh41934596870a50e8e306d0fa'
```

	firstName	abgLabItem	abgLabValue	labItemNameID	observationDate	heartRate	respiration	saO2	temperature	systemicSystolic	chemLabItem
1	RALPH	HCO3	36.7000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Magnesium I
2	RALPH	HCO3	30.8000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Magnesium I
3	RALPH	HCO3	28.5000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Magnesium I
4	RALPH	HCO3	37.8000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Magnesium I
5	RALPH	HCO3	28.5000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Phosphorus
6	RALPH	HCO3	37.8000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Phosphorus
7	RALPH	HCO3	30.8000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Phosphorus
8	RALPH	HCO3	36.7000	492072c8c46742aeb0bcfd6063c2cca4	2017-08-22 17:31:00.000	93	16	96	0.0000	159	Phosphorus

Query executed successfully. 163.246.238.109 (11.0 SP2) | bmsql (60) | archiveDB | 00:00:00 | 3000 rows

Complex queries pulls data from the eICU ArchiveDB in real-time



```
RALPH,HCO3,30.8000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:31:00.000,93,16,96,0.0000,159,Phosphorus Level,3.6000,d1dcb
RALPH,HCO3,36.7000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:31:00.000,93,16,96,0.0000,159,Phosphorus Level,3.6000,d1dcb
RALPH,HCO3,36.7000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:31:00.000,93,16,96,0.0000,159,Magnesium Level (mg/dl),1.700
RALPH,HCO3,30.8000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:31:00.000,93,16,96,0.0000,159,Magnesium Level (mg/dl),1.700
RALPH,HCO3,28.5000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:31:00.000,93,16,96,0.0000,159,Magnesium Level (mg/dl),1.700
RALPH,HCO3,37.8000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:31:00.000,93,16,96,0.0000,159,Magnesium Level (mg/dl),1.700
LYNDA,HCO3,19.3000,492072c8c46742aeb0bcfd6063c2cca4,2017-08-22 17:32:00.000,140,20,94,0.0000,0,Potassium,4.9000,3966f6c4fabf4
LYNDA,FiO2,30.0000,6888379d5fcd4cd8b8a4bddc73adb32c,2017-08-22 17:32:00.000,140,20,94,0.0000,0,Potassium,4.9000,3966f6c4fabf4
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```

Unscrambl Platforms Unscrambles this data in real-time!