AI and Perioperative Care

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Associate Professor of Anesthesiology
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WashU Medicine

Learning Objectives

1. To identify the steps involved with training and testing models to predict postoperative complications

2. To analyze the user-centered design considerations used to implement models in real time during surgery

3. To evaluate the effects of AI models on anesthesiology clinicians' ability to identify patients at risk for postoperative complications

Postoperative Death

- 4 million deaths per year worldwide



x 8,000

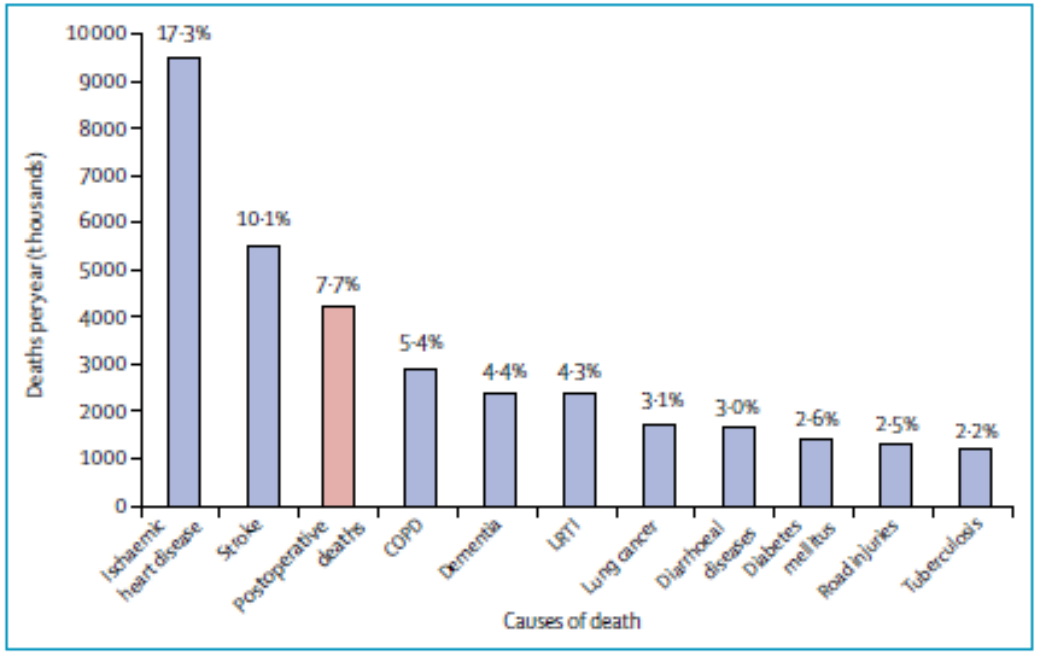


Figure: **Top ten global causes of death, 2016**
Percentages are the proportion of total global deaths attributable to each cause. Data, except those on postoperative deaths, are from the Global Burden of Disease Study 2016.[4] COPD=chronic obstructive pulmonary disease. LRTI=lower respiratory tract infections.

Nepogodiev et al. Lancet 2019; 393: 401

Global patient outcomes after elective surgery: prospective cohort study in 27 low-, middle- and high-income countries

The International Surgical Outcomes Study group†

- 44,814 adult patients undergoing elective inpatient surgery at 474 hospitals in a 7-day period
- 17% of patients developed one or more complications

	N = 44 814	Mortality for patients who developed complications N = 207
Infectious complications		
Superficial surgical site	1320 (2.9)	17/1320 (1.3)
Deep surgical site	566 (1.3)	28/566 (4.9)
Body cavity	340 (0.8)	24/340 (7.0)
Pneumonia	708 (1.6)	55/708 (7.8)
Urinary tract	681 (1.5)	13/681 (1.9)
Bloodstream	417 (0.9)	48/417 (11.5)
Total infectious complications	4032	104/4032 (2.6)
Cardiovascular complications		
Myocardial infarction	139 (0.3)	26/139 (18.7)
Arrhythmia	1222 (2.7)	74/1222 (6.1)
Pulmonary oedema	330 (0.7)	34/330 (10.3)
Pulmonary embolism	78 (0.2)	5/78 (6.4)
Stroke	111 (0.2)	18/111 (16.2)
Cardiac arrest	153 (0.3)	91/153 (59.5)
Total cardiovascular complications	2033	141/2033 (6.9)
Other complications		
Gastrointestinal bleed	201 (0.4)	24/201 (11.9)
Acute kidney injury	778 (1.7)	76/778 (9.8)
Postoperative bleed	1362 (3.0)	55/1362 (4.0)
ARDS	142 (0.3)	34/142 (23.9)
Anastomotic leak	208 (0.5)	21/208 (10.1)
All others	2934 (6.5)	83/2925 (2.8)
Total other complications	5625	158/5625 (2.8)
Total number of complications	11 690	207/7508 (2.8)

Intl Surg Outcomes Study group. Br J Anaest 2016; 117: 601-9

What can we do?

- Early modification of risk factors may change outcomes.
- This requires us to know who is at risk and why.
- There is a lot of information available during surgery that can guide risk assessment, but it's hard for the anesthesiology clinician to put together.

Monk et al. Anesth Analg 2005; 100: 4-10
Salmasi et al. Anesthesiology 2017; 126: 47-65
Futier et al. JAMA 2017; 318: 1346-57
Buschman et al. PNAS 2011; 108: 11252-5
Stiegler & Tung. Anesthesiology 2014; 120: 204-17

While caring for a patient in the operating room, an anesthesia clinician is bombarded with all kinds of sights and sounds that compete for her attention.



Vital sign monitor/alarms



Anesthesia machine/ventilator



Phones ringing



IV pumps beeping



Suction canisters





Pagers beeping



Surgical field

At the same time, the clinician has a long list of things she must do to keep the patient safe and to keep the operating room running smoothly.



Give medications



Administer blood



Place breathing tubes



Set ventilator/watch vital signs





Coordinate care for previous patient and next patient



Start IV lines

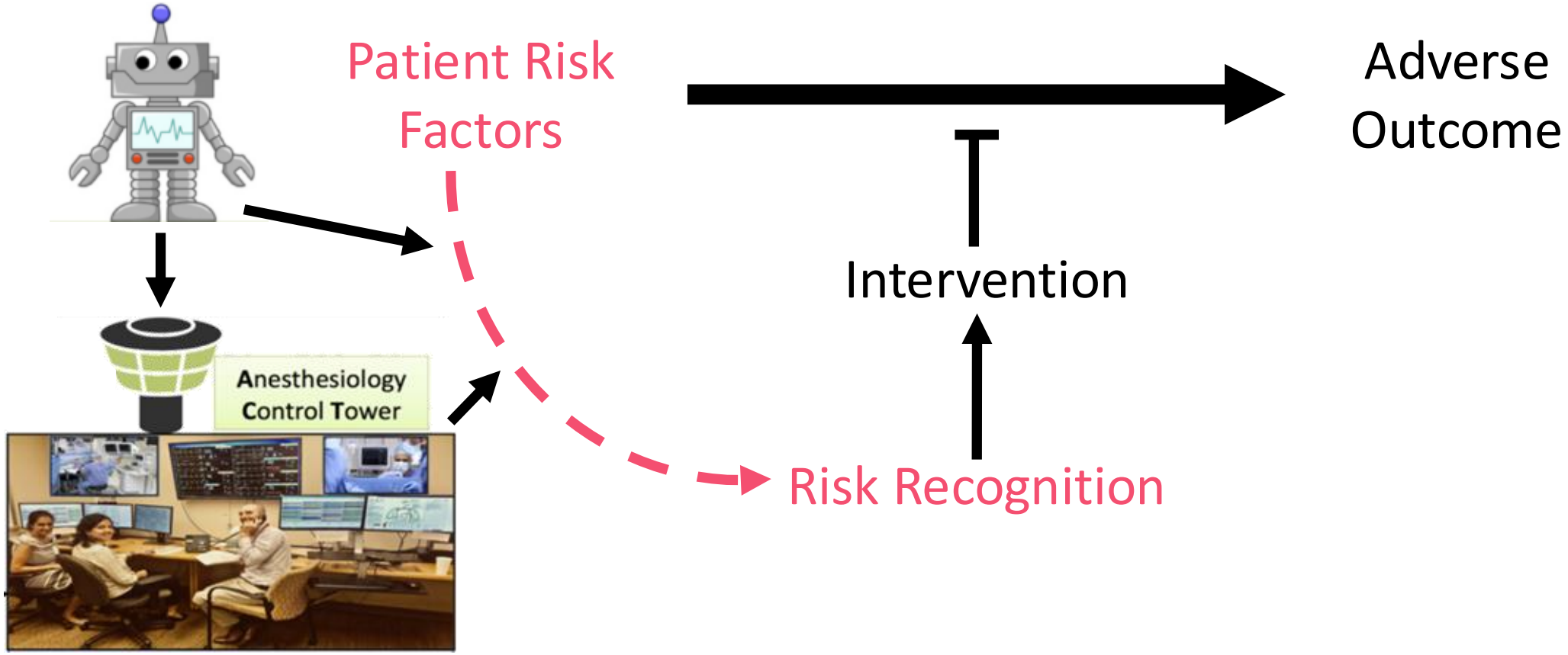


Write orders

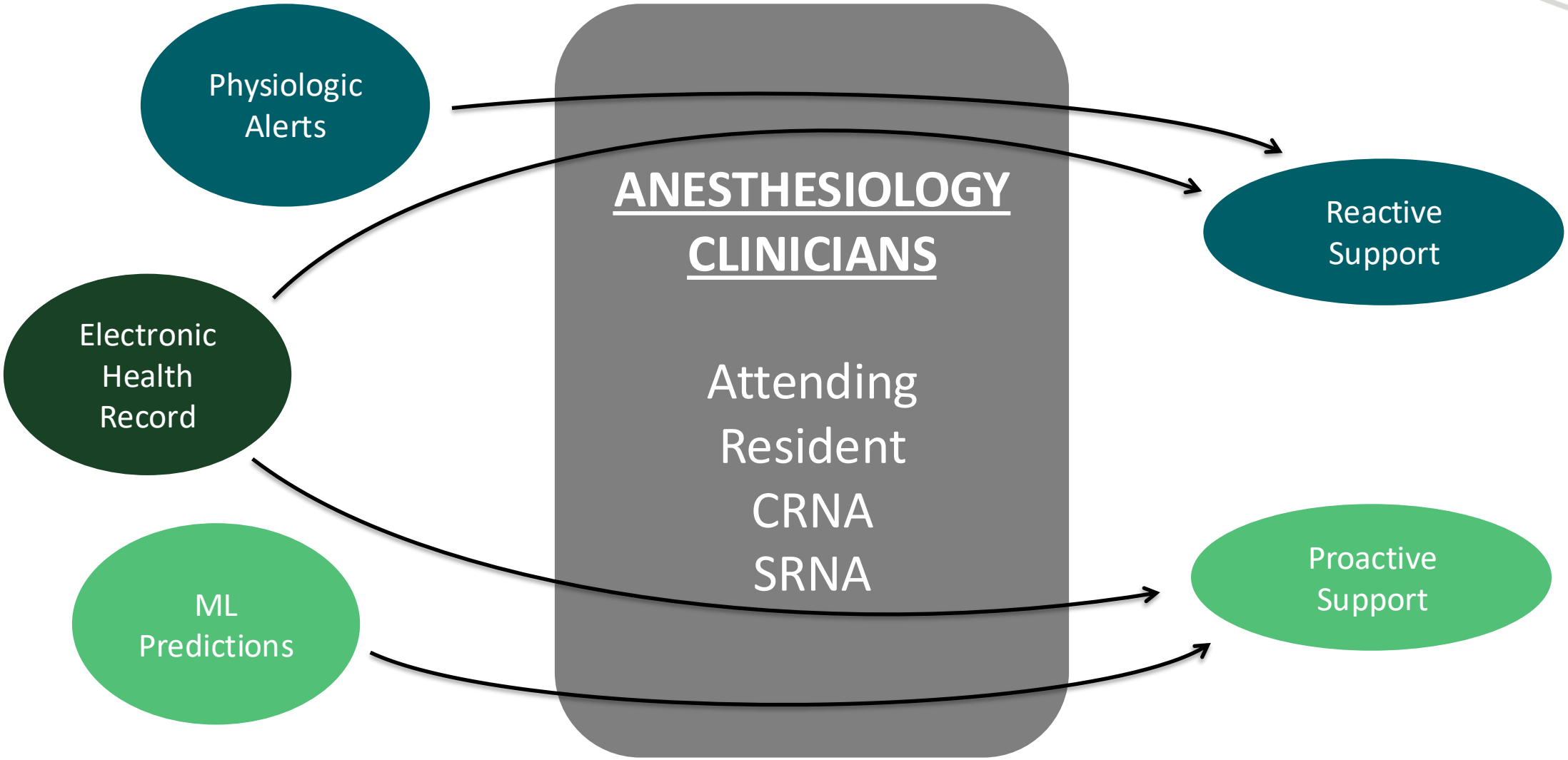


Document in medical record

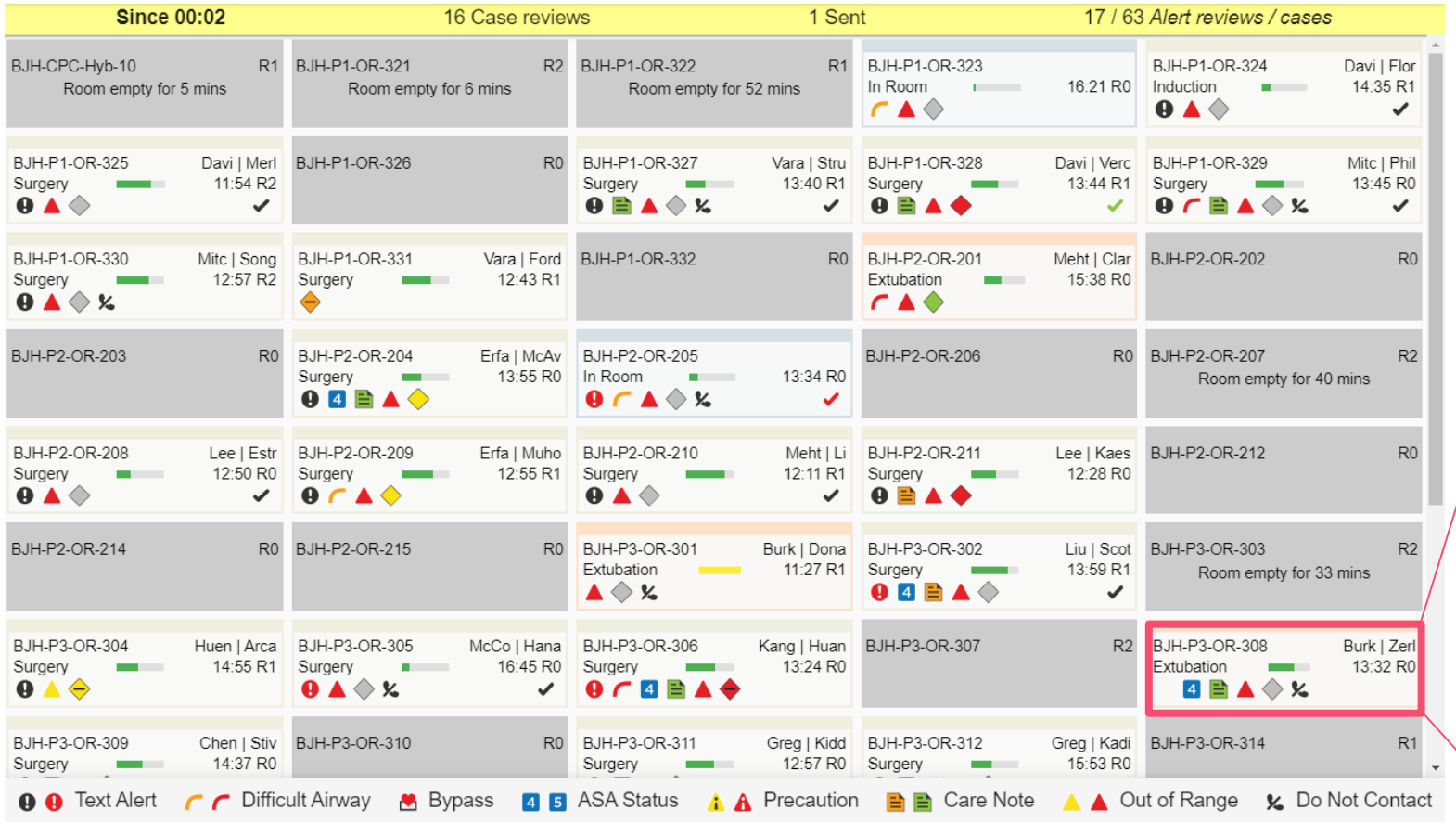
The Scenario



ACT Workflow

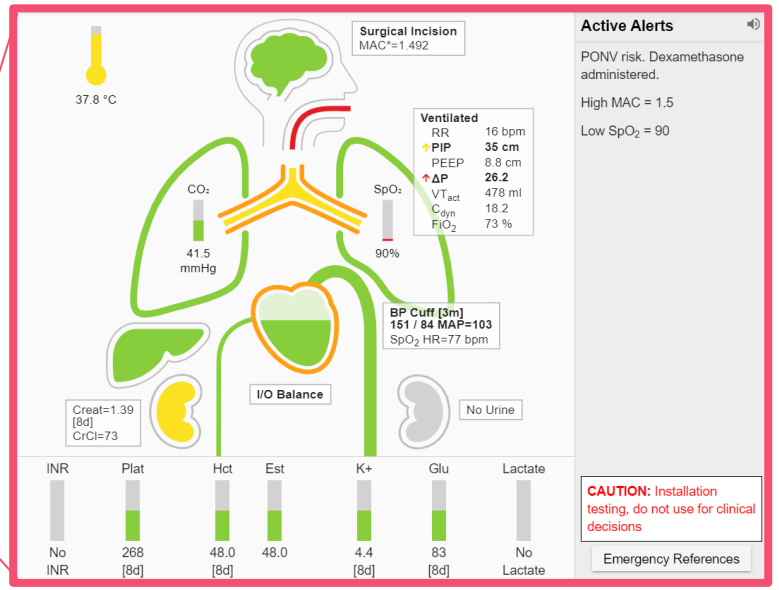


Physiologic Alerts



AlertWatch™

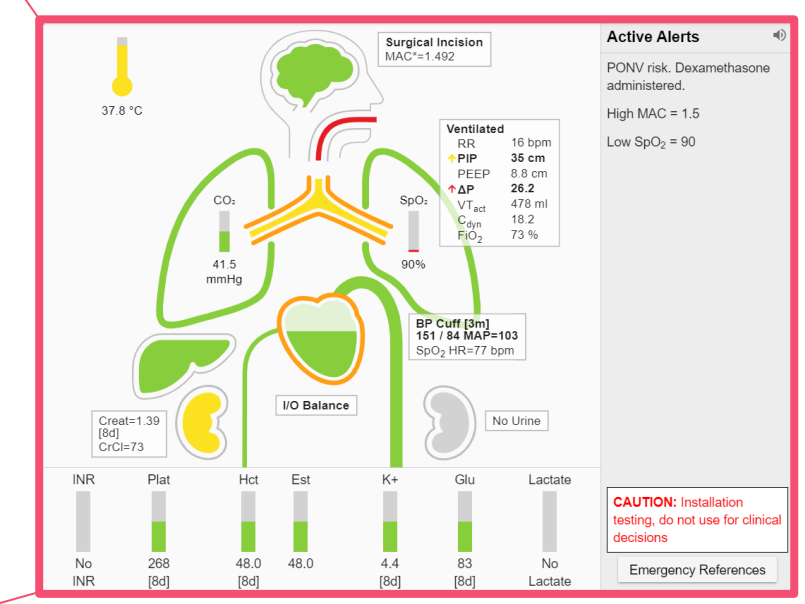




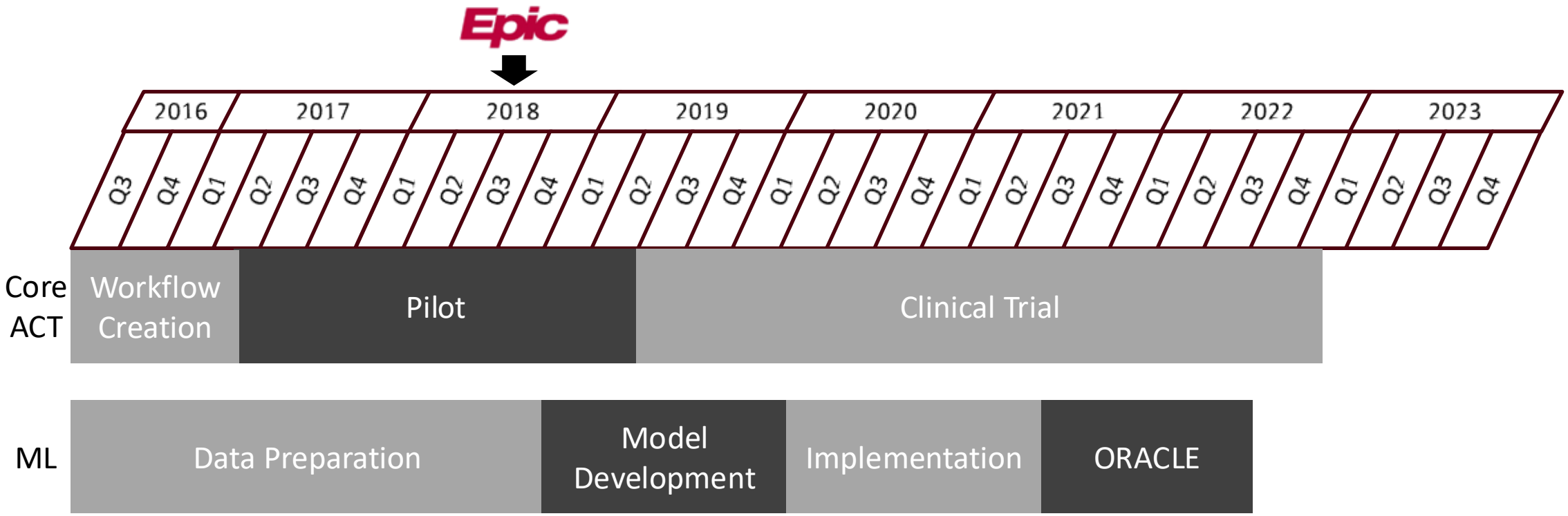
Physiologic Alerts

AlertWatch™

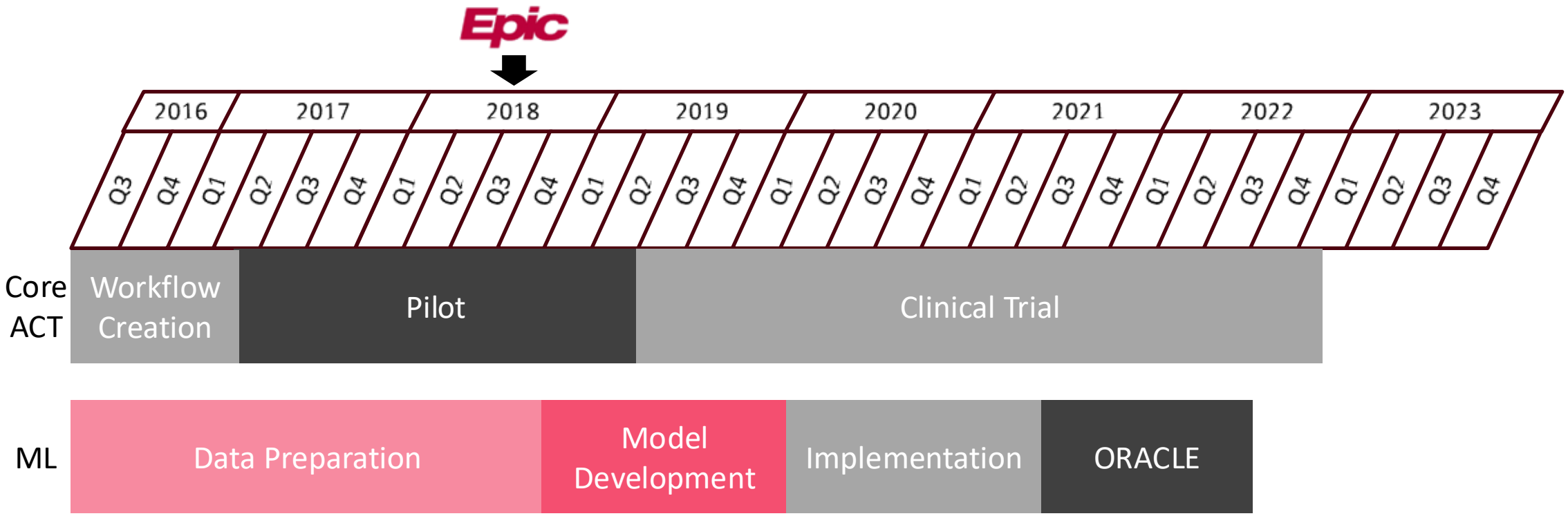
When	Organ	Alert/Issue	Assesment/Action
✔	Brain	**Alert**. Low MAC = 0.6	+ Add Assessment · Snooze · Irrelevant alert, disable for entire case · Not a problem
✔	Labs	**Alert**. Low Temperature = 34.8 °C	+ Add Assessment · Snooze · Irrelevant alert, disable for entire case · Not a problem
✔	General	**Alert**. Consider documenting train of four.	+ Add Assessment · Snooze · Irrelevant alert, disable for entire case · Not a problem
13:46:39	Labs	**Alert**. Temperature not measured.	**Assessment:** Potentially significant, will continue to monitor **Action:** No indication for clinician communication **Reaction:** None
13:43:21	Brain	**Alert**. Low MAC < 0.4 for 8 minutes.	**Assessment:** Significant, inadequately addressed. Unclear etiology **Action:** Other (enter comment) **Reaction:** ACT input did not impact management because ACT recommendations were already being carried out **Comment:** propofol gtt was not charted



ACT Timeline



ACT Timeline



ML Model Development


Ryan King


Yixin Chen

- 2016 – Project launch
- 2018 – Hospital moves to Epic
- 2019 – First model published using data from historic EHR
  N = approx. 111,000
- 2022 – First models to retrain using Epic data
  N = approx. 84,000

KEY CONSIDERATIONS

- Input feature selection
- Prediction target definitions
- Aligning data from disparate sources

Data Collection



Alex Kronzer

Surgery at BJH
6/2012 – 8/2016
(N = 111,890)

CPAP/IPAP Assessment
- Age/sex/race
- Comorbid conditions
- Surgery type
- Preoperative vital signs

Anesthesia Record
- ASA physical status
- Vital signs
- Ventilator readings
- Medications

Preoperative Labs
- CBC, CMP, Coags

Postoperative Labs
- Creatinine (AKI)

Respiratory Failure

BJC *Mortality*

Data Processing – Key Considerations

- DEMOGRAPHIC CHARACTERISTICS, MEDICAL HISTORY
  - Low missing rates (other than trauma DOE patients, emergency surgeries)

- LABORATORY TESTS
  - Missing data
    - ***NOT*** missing at random
    - Deciding not to check a lab test tells you something about the patient
  - Harmonizing similar lab tests
    - E.g., blood glucose run by lab versus blood glucose point-of-care test

Data Processing – Key Considerations

- VITAL SIGNS
  - Artifact detection
    - Implausibly high or low values
  - Blood pressure: noninvasive versus invasive
    - Different levels of accuracy
    - Different time intervals
    - Nonrandom selection of blood pressure modality
  - How to handle time series data
    - Most recent value
    - Manually engineered summary variables
    - Model architectures that directly handle time series

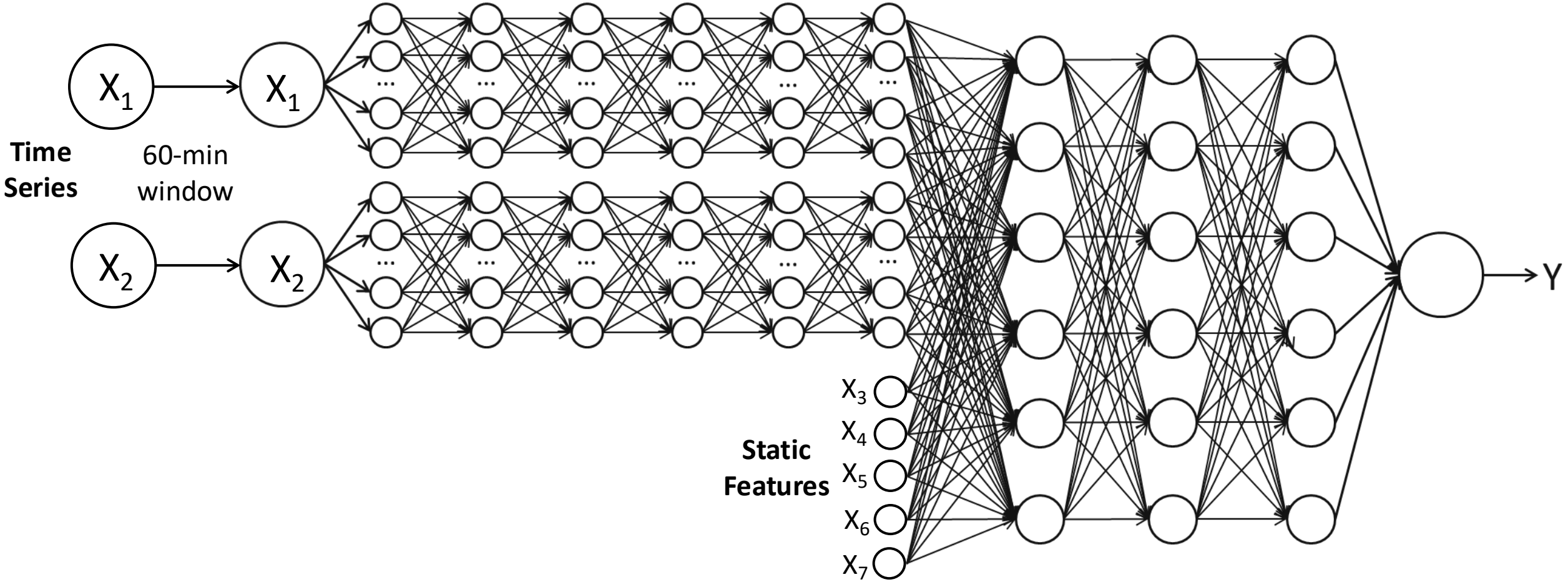




Model 1: Multi-path convolutional neural network

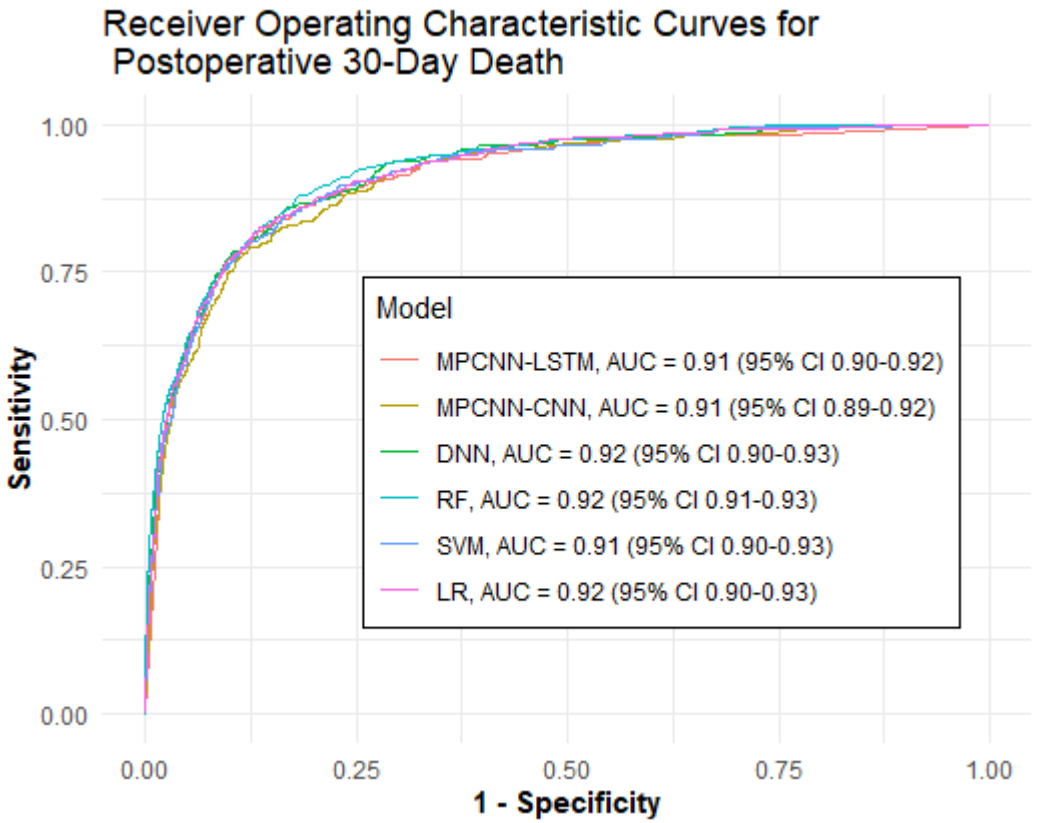


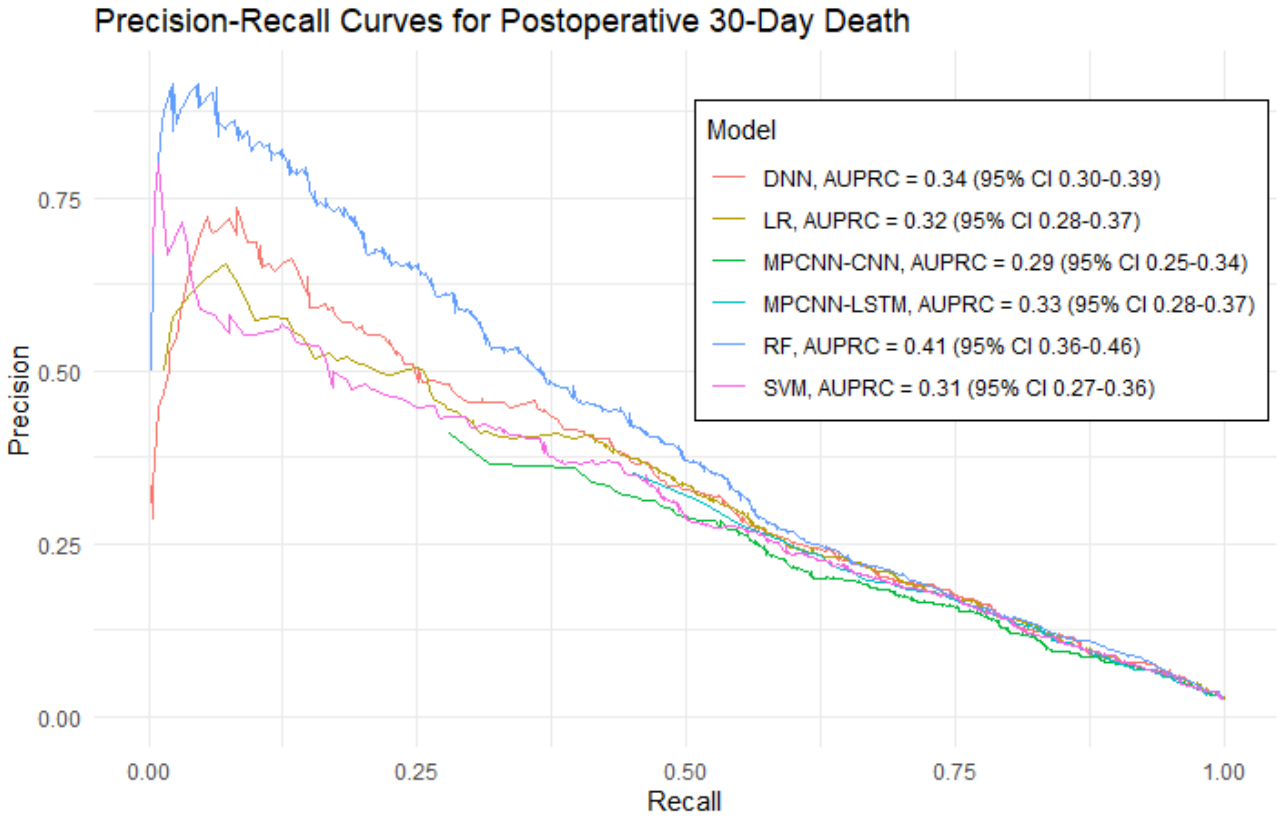
Zhicheng Cui



Fritz, et al. Br J Anaesth 2019; 123: 688-95
Fritz, et al. Br J Anaesth 2020; 125:e230-1

Mortality Prediction





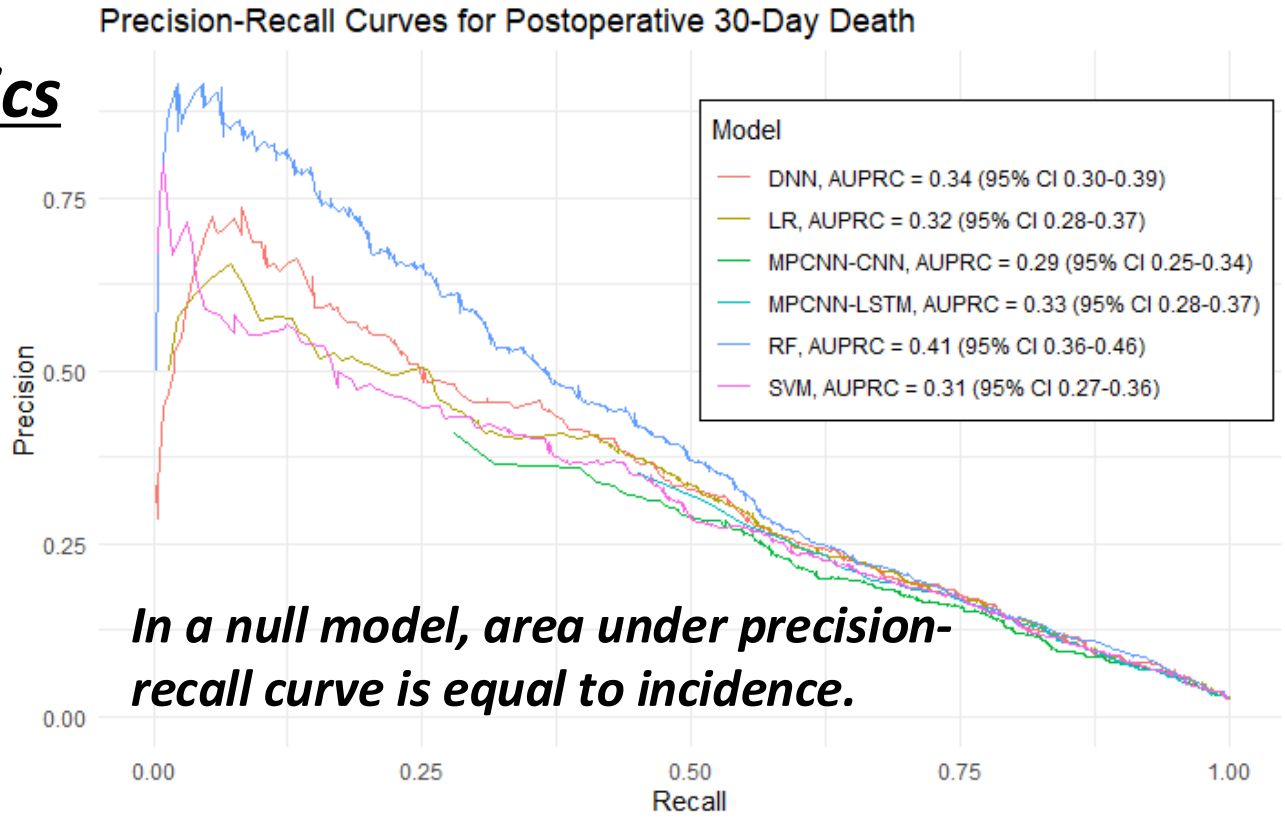
Fritz, et al. Br J Anaesth 2019; 123: 688-95
Fritz, et al. Br J Anaesth 2020; 125:e230-1

Mortality Prediction

Common Model Performance Metrics

Precision – Fraction of positive predictions that are true events
(Positive Predictive Value)

Recall – Fraction of true events that are correctly predicted
(Sensitivity)



In a null model, area under precision-recall curve is equal to incidence.

Fritz, et al. Br J Anaesth 2019; 123: 688-95
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Contents lists available at ScienceDirect

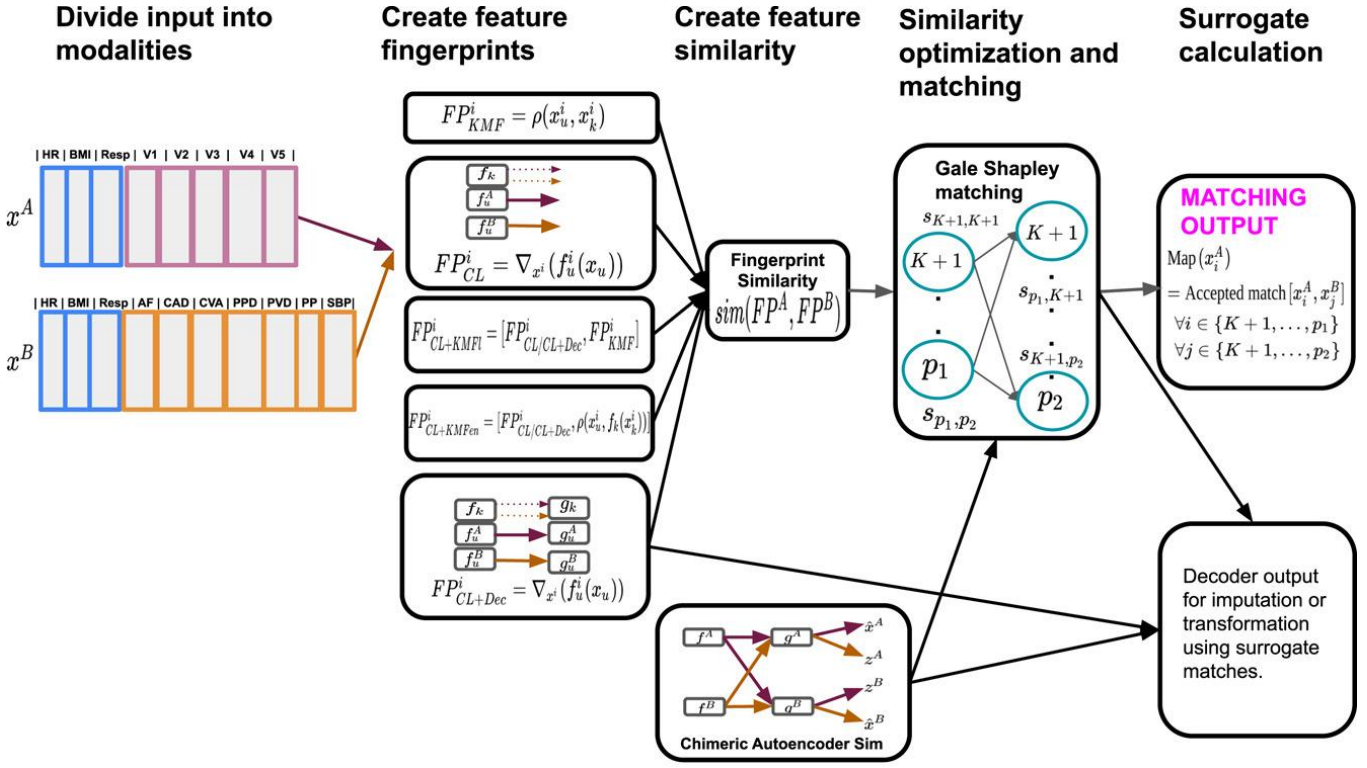
Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

Original Research

Multi-view representation learning for tabular data integration using inter-feature relationships

Sandhya Tripathi [a,*], Bradley A. Fritz [a], Mohamed Abdelhack [c], Michael S. Avidan [a], Yixin Chen [b], Christopher R. King [a]



Tripathi et al. J Biomed Inform 2024; 151: 104602

Model Updates


Sandhya Tripathi

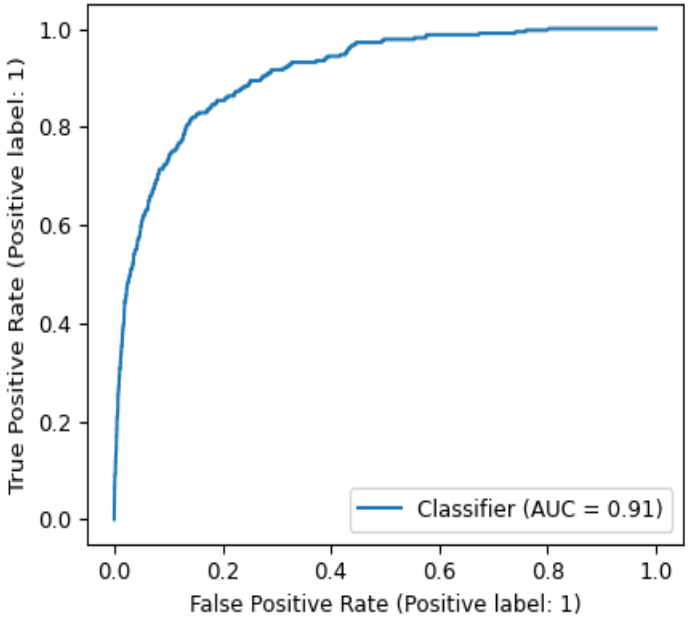

Mohammed Abdelhack

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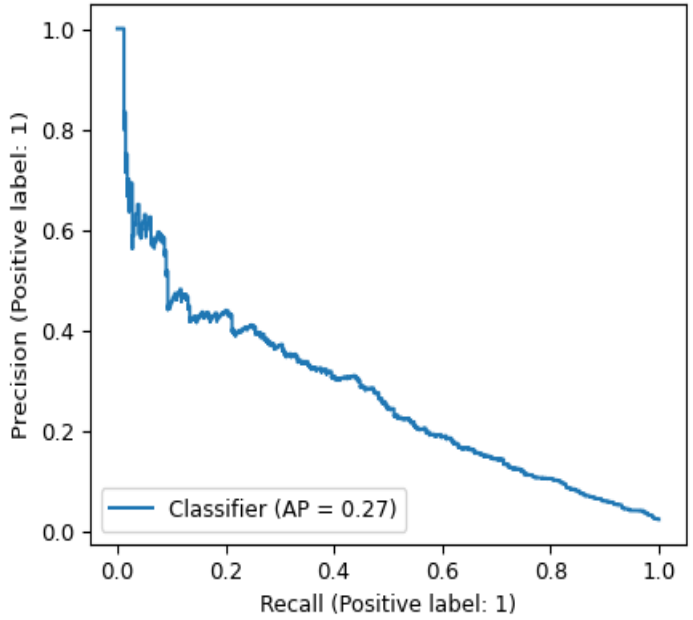
- Repeat Training
  - N = 84,455
  - Surgery with general anesthesia at BJH
  - Aug 2018 through Jan 2020 (Epic era)
- Architecture
  - Gradient boosted decision tree
    - Demographics, comorbidities, preop vitals, labs
    - Text of planned surgical procedure

Model Updates

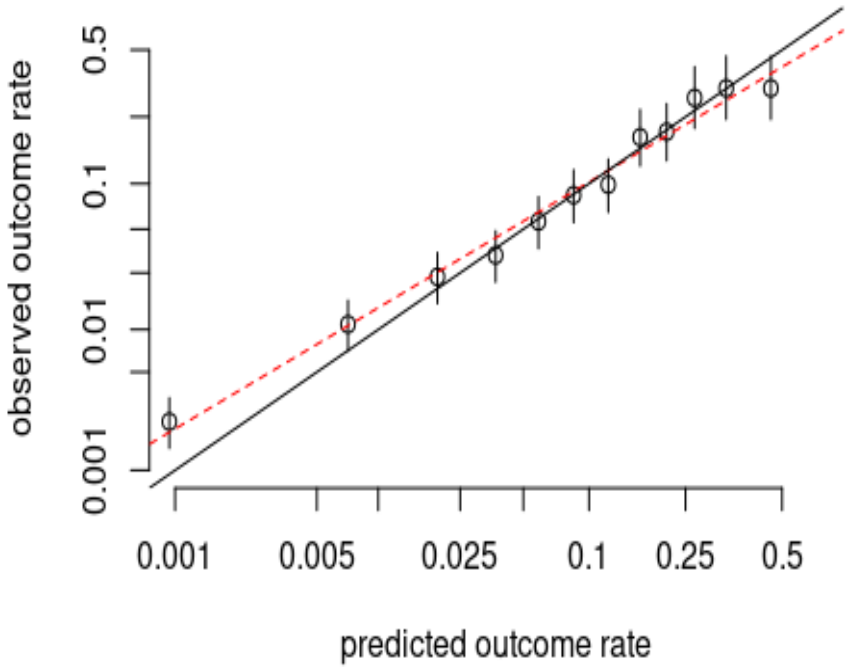
Death within 30 days



Death within 30 days



Death within 30 days



Implementation



ACTFAST Early Warning System



Ryan King



Nic Labee

☑ Hide Empty Rooms

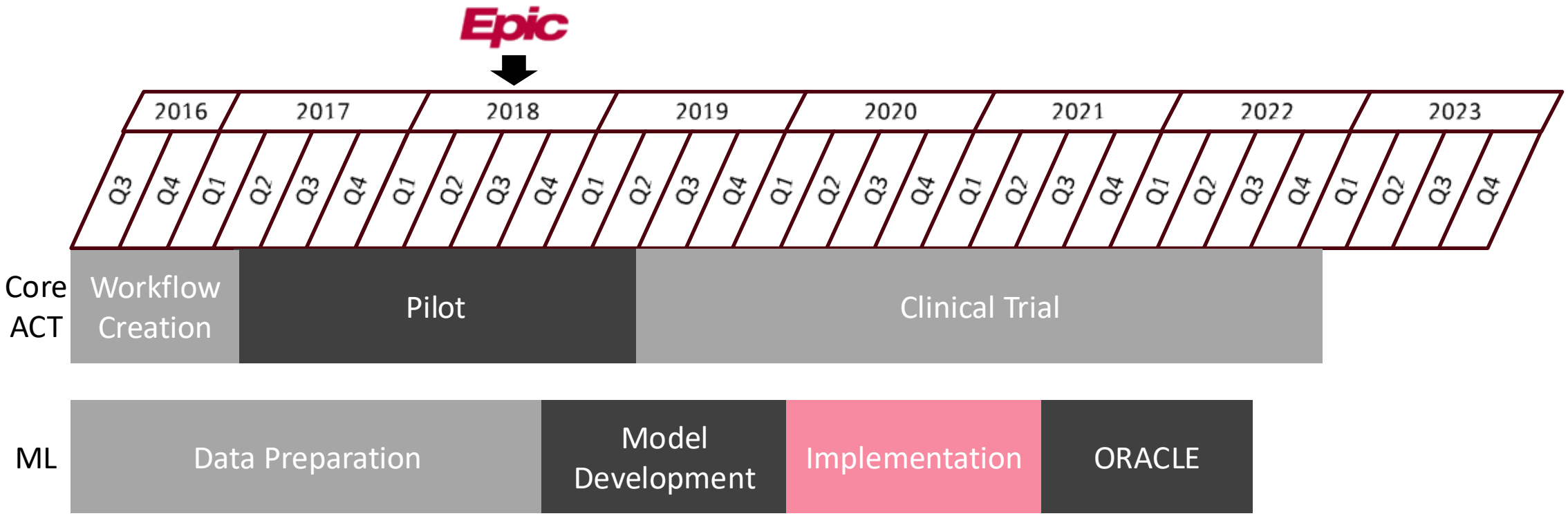
Alert On

Needs Review

Search:

		Room Name	Description	Last Prediction									Occupied Since
				akigr1	cardiac	death_in_30	DVT_PE	ICU	long_vent	post_dialysis	pulm	transfusion	
⊕	Details	BJH OR POD 3 ROOM 306	BYPASS GRAFT - AXILLO FEMORAL REPAIR PSEUDOANEURYSM LEFT GROIN DISSECTION GROIN MUSCLE FLAP	37.00%	1.70%	1.60%	1.00%	19.20%	17.50%	0.30%	0.50%	38.10%	
⊕	Details	BJH OR POD 3 ROOM 314	Endoluminal Repair Thoracoabdominal Aneurysm	41.50%	6.20%	0.70%	8.20%	56.70%	3.20%	0.10%	0.10%	8.00%	
⊕	Details	BJH OR POD 5 ROOM 223	EXPLORATION WOUND HEAD/NECK FREE FLAP MICROVASCULAR REANASTAMOSIS FREE FLAP RADIAL FOREARM	7.10%	4.70%	6.40%	1.00%	69.20%	12.10%	0.00%	1.10%	86.60%	
⊕	Details	BJH OR POD 1 ROOM 322	LAPAROSCOPIC SALPINGECTOMY	0.10%	0.10%	0.00%	0.10%	0.20%	0.10%	0.00%	0.00%	0.10%	
⊕	Details	BJH OR POD 1 ROOM 323	DEBRIDEMENT - PERINEUM EXCHANGE WOUND VACUUM	15.10%	2.60%	0.40%	1.10%	16.10%	21.20%	0.60%	0.10%	42.00%	
⊕	Details	BJH OR POD 1 ROOM 325	WASHOUT ABDOMEN RESECTION SMALL BOWEL REVISION COLOSTOMY	46.70%	11.70%	9.80%	1.90%	63.60%	65.00%	0.40%	1.40%	35.90%	

ACT Timeline



ORIGINAL CLINICAL RESEARCH REPORT

User-Centered Design of a Machine Learning Dashboard for Prediction of Postoperative Complications

Bradley A. Fritz, MD, MSCI,* Sangami Pugazenthi, BA,* Thaddeus P. Budelier, MD, MSF,* Bethany R. Tellor Pennington, PharmD,* Christopher R. King, MD, PhD,* Michael S. Avidan, MBBCh,* and Joanna Abraham,PhD*†



Joanna Abraham

Phase One
Focus Group Needs Assessment

- Semi-structured interviews
- Card sorting

Creation of low-fidelity prototype based on results from Phase One

Phase Two
Evaluation of Low-Fidelity Prototype

- Semi-structured interviews

Creation of high-fidelity prototype based on results from Phase Two

Phase Three
Usability of High-Fidelity Prototype

- Concurrent think-aloud
- Semi-structured interviews
- System Usability Scale

Fritz, et al. Anesth Analg 2023; 138: 804-813

Focus Groups (N = 6)

- Semi-structured interviews
  - Workflow for choosing a patient to evaluate
  - Workflow for comprehensive case review
  - Workflow for estimating patient risk for postoperative complications
- Card sorting activity to select display elements
- Open discussion of display format preferences

Key Findings

- Clinicians perform case reviews using a **systematic approach**

  "If I decide to review a case, I usually will kind of do it as if I was preparing for it myself." – Participant 1 (CRNA)

  8 participants explicitly stated they start with the note from the pre-anesthesia clinic

- Clinicians want to identify patients where they can **take action** to prevent complications

  "What you want is modifiable—things you can do. History of hypertension? You're not going to be able to do anything about that." – Participant 4 (Attending)

Key Findings

- Clinicians want **display formats** that minimize the energy and time spent interpreting data
  - Simplicity — *"If you get too much information you get information overload and you can't use it. So, I agree with that, the right amount of information at the right time, whatever that means." – Participant 11 (Attending)*
  - Color — *"We're all so color sensitive. … So like for me, by including red stuff on there, my brain just knows, I keep thinking I need to look at that first." – Participant 3 (CRNA)*
  - Graphs — *"For some reason, I look at the graph and I can assimilate that information quicker, and it requires less brain cells to digest." –Participant 20 (Resident)*

Card Sort

Display Element	Include in Display? (Consensus within Focus Group, N = 6)			
	Yes	Maybe	No	Undecided
Scheduled surgery	6 (100%)	0 (0%)	0 (0%)	0 (0%)
Variables contributing to prediction	6 (100%)	0 (0%)	0 (0%)	0 (0%)
Quantitative predicted risk (numeric)	5 (83%)	1 (17%)	0 (0%)	0 (0%)
Change in last 15 minutes	5 (83%)	1 (17%)	0 (0%)	0 (0%)
Age	3 (50%)	3 (50%)	0 (0%)	0 (0%)
Preoperative prediction	2 (33%)	3 (50%)	0 (0%)	1 (17%)
Qualitative predicted risk (high/average/low)	2 (33%)	3 (50%)	1 (17%)	0 (0%)
Patient identifiers	2 (33%)	1 (17%)	1 (17%)	2 (33%)
Average prediction for same surgery	1 (17%)	5 (83%)	0 (0%)	0 (0%)
Confidence interval around prediction	1 (17%)	5 (83%)	0 (0%)	0 (0%)
Average prediction for same age	0 (0%)	5 (83%)	1 (17%)	0 (0%)
Average prediction for entire hospital	0 (0%)	0 (0%)	6 (100%)	0 (0%)

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Joanna Abraham

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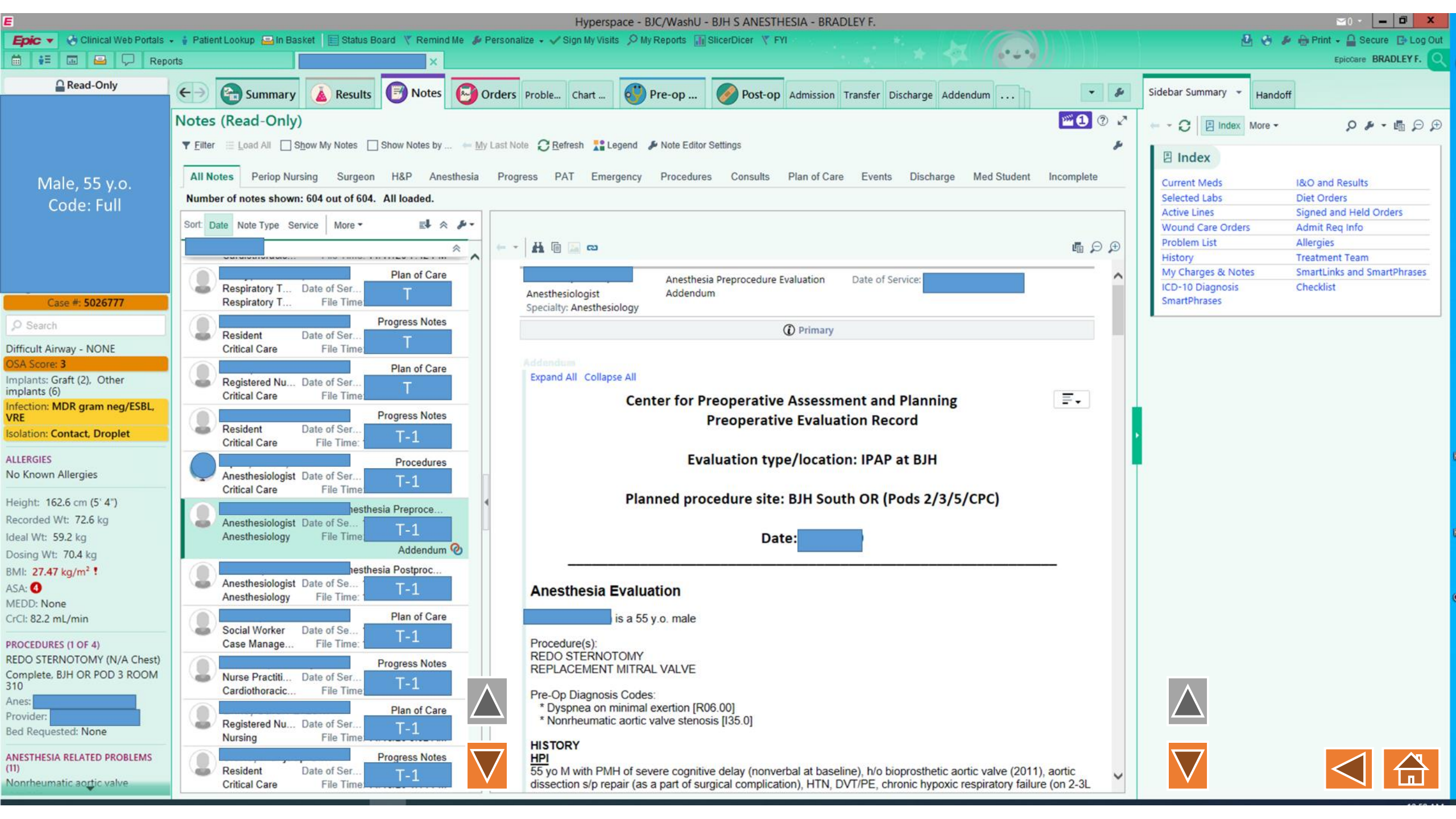
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Usability of High-Fidelity Prototype

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Fritz, et al. Anesth Analg 2023; 138: 804-813


Hyperspace - BJC/WashU - BJH S ANESTHESIA - BRADLEY F.
Epic
Clinical Web Portals
Patient Lookup
In Basket
Status Board
Remind Me
Personalize
Sign My Visits
My Reports
SlicerDicer
FYI
Print
Secure
Log Out
Reports
EpicCare BRADLEY F.
Read-Only
Male, 55 y.o.
Code: Full
Case #: 5026777
Search
Difficult Airway - NONE
OSA Score: 3
Implants: Graft (2), Other implants (6)
Infection: MDR gram neg/ESBL, VRE
Isolation: Contact, Droplet
ALLERGIES
No Known Allergies
Height: 162.6 cm (5' 4")
Recorded Wt: 72.6 kg
Ideal Wt: 59.2 kg
Dosing Wt: 70.4 kg
BMI: 27.47 kg/m² !
ASA: 4
MEDD: None
CrCl: 82.2 mL/min
PROCEDURES (1 OF 4)
REDO STERNOTOMY (N/A Chest)
Complete, BJH OR POD 3 ROOM 310
Anes:
Provider:
Bed Requested: None
ANESTHESIA RELATED PROBLEMS (11)
Nonrheumatic aortic valve
Summary
Results
Notes
Orders
Proble...
Chart ...
Pre-op ...
Post-op
Admission
Transfer
Discharge
Addendum
Sidebar Summary
Handoff
Notes (Read-Only)
Filter
Load All
Show My Notes
Show Notes by ...
My Last Note
Refresh
Legend
Note Editor Settings
All Notes
Periop Nursing
Surgeon
H&P
Anesthesia
Progress
PAT
Emergency
Procedures
Consults
Plan of Care
Events
Discharge
Med Student
Incomplete
Number of notes shown: 604 out of 604. All loaded.
Sort: Date
Note Type
Service
More
Plan of Care
Respiratory T... Date of Ser...
Respiratory T... File Time
T
Progress Notes
Resident Date of Ser...
Critical Care File Time
T
Plan of Care
Registered Nu... Date of Ser...
Critical Care File Time
T
Progress Notes
Resident Date of Ser...
Critical Care File Time:
T-1
Procedures
Anesthesiologist Date of Ser...
Critical Care File Time
T-1
esthesia Preproce...
Anesthesiologist Date of Se...
Anesthesiology File Time
T-1
Addendum
esthesia Postproc...
Anesthesiologist Date of Se...
Anesthesiology File Time:
T-1
Plan of Care
Social Worker Date of Se...
Case Manage... File Time:
T-1
Progress Notes
Nurse Practiti... Date of Ser...
Cardiothoracic... File Time
T-1
Plan of Care
Registered Nu... Date of Ser...
Nursing File Time
T-1
Progress Notes
Resident Date of Ser...
Critical Care File Time
T-1
Anesthesiologist
Specialty: Anesthesiology
Anesthesia Preprocedure Evaluation
Addendum
Date of Service:
Primary
Addendum
Expand All
Collapse All
Center for Preoperative Assessment and Planning
Preoperative Evaluation Record
Evaluation type/location: IPAP at BJH
Planned procedure site: BJH South OR (Pods 2/3/5/CPC)
Date:
Anesthesia Evaluation
is a 55 y.o. male
Procedure(s):
REDO STERNOTOMY
REPLACEMENT MITRAL VALVE
Pre-Op Diagnosis Codes:
* Dyspnea on minimal exertion [R06.00]
* Nonrheumatic aortic valve stenosis [I35.0]
HISTORY
HPI
55 yo M with PMH of severe cognitive delay (nonverbal at baseline), h/o bioprosthetic aortic valve (2011), aortic dissection s/p repair (as a part of surgical complication), HTN, DVT/PE, chronic hypoxic respiratory failure (on 2-3L
Index
More
Index
Current Meds
Selected Labs
Active Lines
Wound Care Orders
Problem List
History
My Charges & Notes
ICD-10 Diagnosis
SmartPhrases
I&O and Results
Diet Orders
Signed and Held Orders
Admit Req Info
Allergies
Treatment Team
SmartLinks and SmartPhrases
Checklist

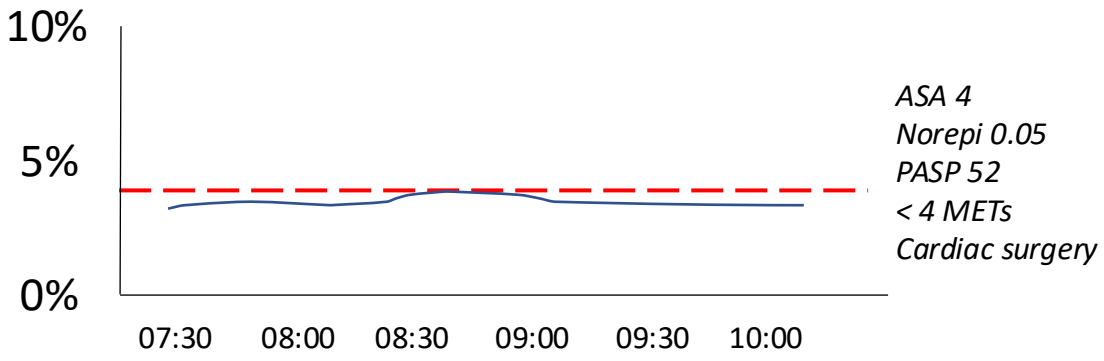
OR	Death	Acute Kidney Injury	Respiratory Failure	Myocardial Infarction
202	0.5%	2%	1%	0.5%
211	6%	35%	40%	5%
219	2%	10%	3%	2%
234	0%	1%	1%	4%
301	5%	32%	10%	7%
307	1%	24%	2%	8%
310	4%	13%	33%	4%
311	3%	18%	12%	3%
322	4%	28.5%	10%	5%
324	0%	2%	1%	0%

OR 310

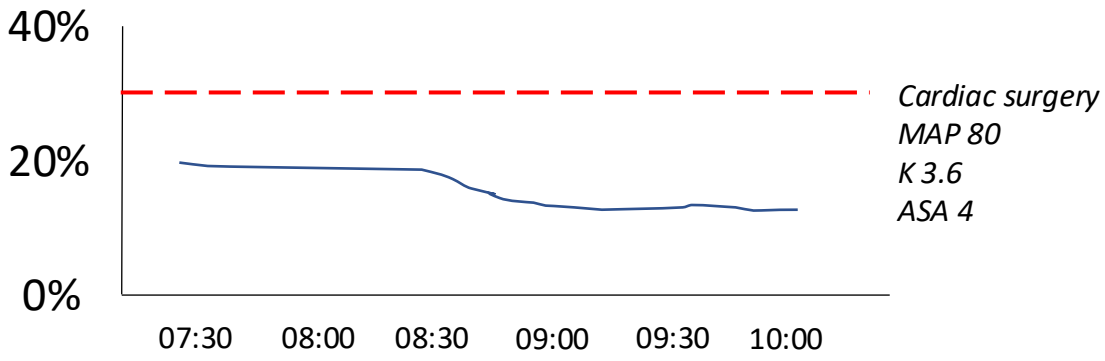
Redo sternotomy, mitral valve replacement

Average for mitral valve replacements

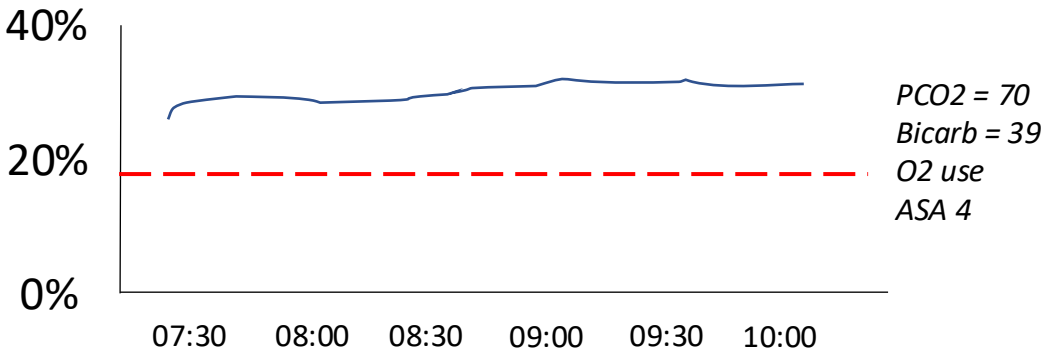
Death 4%



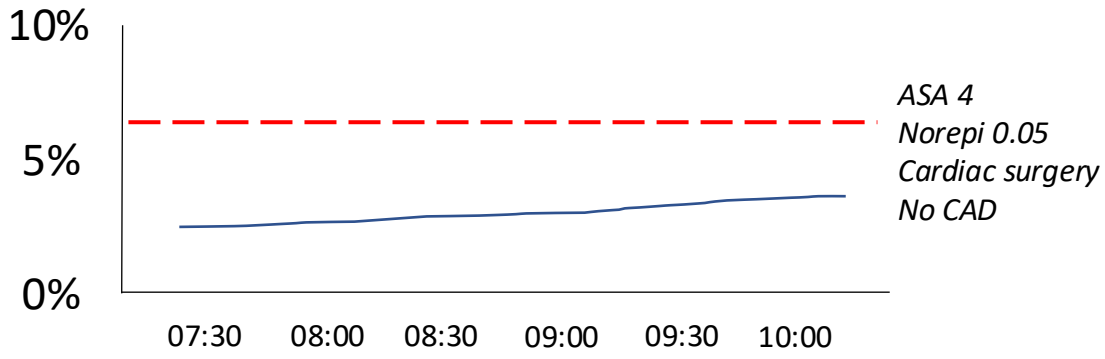
Acute Kidney Injury 13%



Respiratory Failure 33%



Myocardial Infarction 4%



Key Findings

- Users found ML display to be **beneficial** for risk estimation

> *"That is something I struggle with in the ACT tower every time—just applying a risk value to a patient when there's a number of variables. And I feel like the display the machine learning provided was informative." – Participant 6 (CRNA)*

> *"I feel like I have that kind of gestalt if someone's going to be okay, but it's nice to see the numbers. It's really nice to see the numbers." – Participant 9 (Attending)*

Key Findings

- Users want the display to **tell them what to do**

  "It would be useful for me here for the machine learning to suggest these outcomes rather than me picking them. … It'd be wonderful if the machine suggested things and then we could modify it." –Participant 5 (Attending)

  "It'd be helpful to know if any of them [contributing features] are modifiable." – Participant 2 (Attending)

- **Labels** were inadequate

  "It would be useful to know what the definition [of the complication] is, just briefly." – Participant 8 (Attending)

  "If I weren't being guided, I wouldn't necessarily know that OR room is the place to click." – Participant 6 (CRNA)

ORIGINAL CLINICAL RESEARCH REPORT

User-Centered Design of a Machine Learning Dashboard for Prediction of Postoperative Complications

Bradley A. Fritz, MD, MSCI,* Sangami Pugazenthi, BA,* Thaddeus P. Budelier, MD, MSF,*
Bethany R. Tellor Pennington, PharmD,* Christopher R. King, MD, PhD,* Michael S. Avidan, MBBCh,* and
Joanna Abraham,PhD*†



Joanna Abraham

Phase One
Focus Group Needs Assessment

- Semi-structured interviews
- Card sorting

Creation of low-fidelity prototype based on results from Phase One

Phase Two
Evaluation of Low-Fidelity Prototype

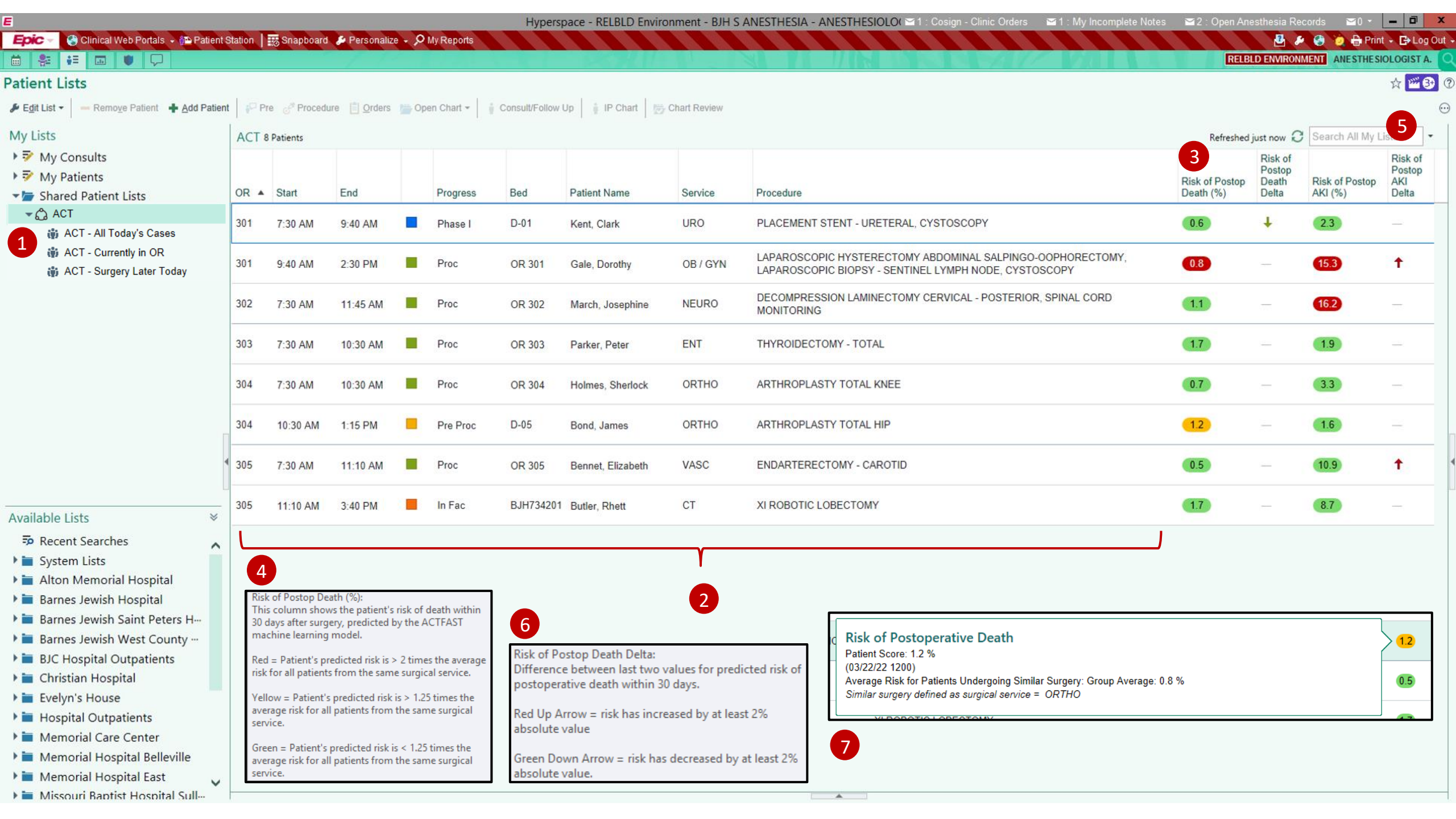
- Semi-structured interviews

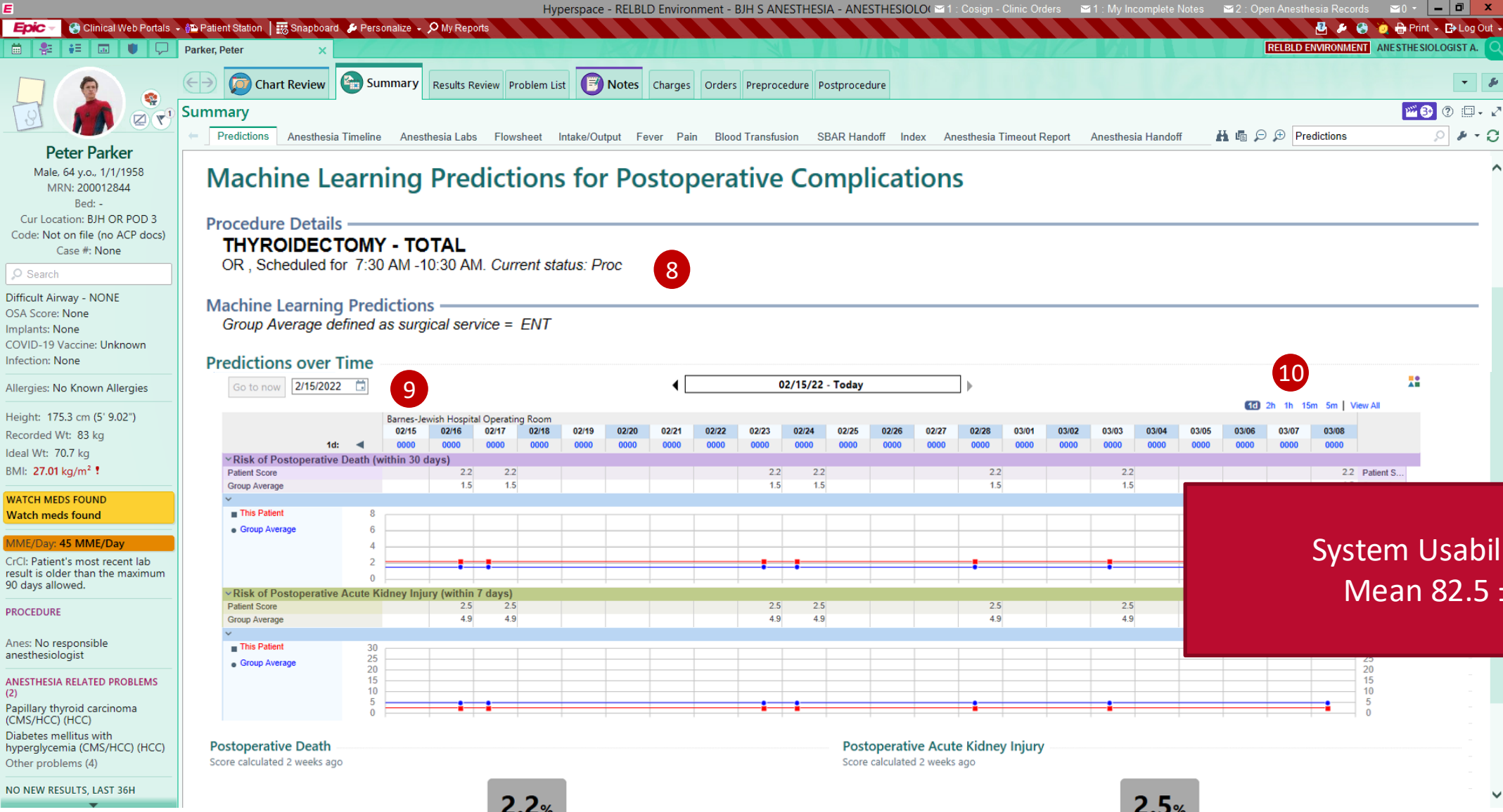
Creation of high-fidelity prototype based on results from Phase Two

Phase Three
Usability of High-Fidelity Prototype

- Concurrent think-aloud
- Semi-structured interviews
- System Usability Scale

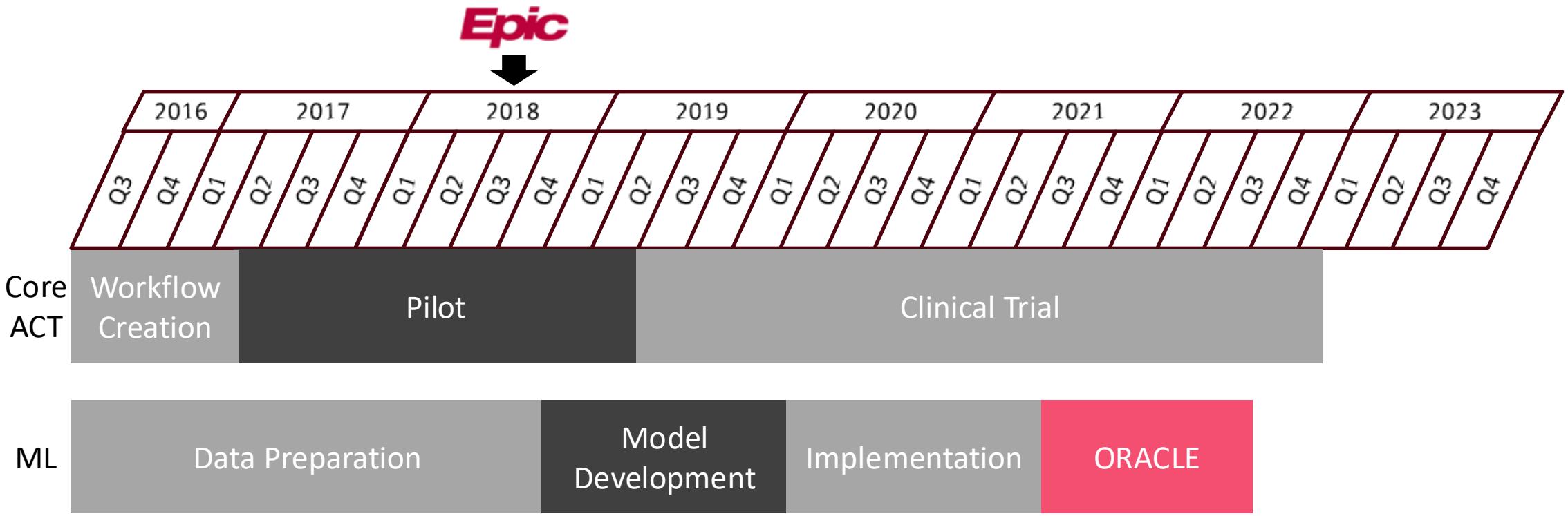
Fritz, et al. Anesth Analg 2023; 138: 804-813


Hyperspace - RELBLD Environment - BJH S ANESTHESIA - ANESTHESIOLO
1 : Cosign - Clinic Orders
1 : My Incomplete Notes
2 : Open Anesthesia Records
Epic
Clinical Web Portals
Patient Station
Snapboard
Personalize
My Reports
Print
Log Out
RELBLD ENVIRONMENT
ANESTHESIOLOGIST A.
Patient Lists
Edit List
Remove Patient
Add Patient
Pre
Procedure
Orders
Open Chart
Consult/Follow Up
IP Chart
Chart Review
My Lists
My Consults
My Patients
Shared Patient Lists
ACT
ACT - All Today's Cases
ACT - Currently in OR
ACT - Surgery Later Today
ACT 8 Patients
Refreshed just now
Search All My Lis
OR
Start
End
Progress
Bed
Patient Name
Service
Procedure
Risk of Postop Death (%)
Risk of Postop Death Delta
Risk of Postop AKI (%)
Risk of Postop AKI Delta
301 7:30 AM 9:40 AM Phase I D-01 Kent, Clark URO PLACEMENT STENT - URETERAL, CYSTOSCOPY 0.6 2.3
301 9:40 AM 2:30 PM Proc OR 301 Gale, Dorothy OB / GYN LAPAROSCOPIC HYSTERECTOMY ABDOMINAL SALPINGO-OOPHORECTOMY, LAPAROSCOPIC BIOPSY - SENTINEL LYMPH NODE, CYSTOSCOPY 0.8 15.3
302 7:30 AM 11:45 AM Proc OR 302 March, Josephine NEURO DECOMPRESSION LAMINECTOMY CERVICAL - POSTERIOR, SPINAL CORD MONITORING 1.1 16.2
303 7:30 AM 10:30 AM Proc OR 303 Parker, Peter ENT THYROIDECTOMY - TOTAL 1.7 1.9
304 7:30 AM 10:30 AM Proc OR 304 Holmes, Sherlock ORTHO ARTHROPLASTY TOTAL KNEE 0.7 3.3
304 10:30 AM 1:15 PM Pre Proc D-05 Bond, James ORTHO ARTHROPLASTY TOTAL HIP 1.2 1.6
305 7:30 AM 11:10 AM Proc OR 305 Bennet, Elizabeth VASC ENDARTERECTOMY - CAROTID 0.5 10.9
305 11:10 AM 3:40 PM In Fac BJH734201 Butler, Rhett CT XI ROBOTIC LOBECTOMY 1.7 8.7
1
2
3
4
5
6
7
Available Lists
Recent Searches
System Lists
Alton Memorial Hospital
Barnes Jewish Hospital
Barnes Jewish Saint Peters H...
Barnes Jewish West County ...
BJC Hospital Outpatients
Christian Hospital
Evelyn's House
Hospital Outpatients
Memorial Care Center
Memorial Hospital Belleville
Memorial Hospital East
Missouri Baptist Hospital Sull...
Risk of Postop Death (%):
This column shows the patient's risk of death within 30 days after surgery, predicted by the ACTFAST machine learning model.
Red = Patient's predicted risk is > 2 times the average risk for all patients from the same surgical service.
Yellow = Patient's predicted risk is > 1.25 times the average risk for all patients from the same surgical service.
Green = Patient's predicted risk is < 1.25 times the average risk for all patients from the same surgical service.
Risk of Postop Death Delta:
Difference between last two values for predicted risk of postoperative death within 30 days.
Red Up Arrow = risk has increased by at least 2% absolute value
Green Down Arrow = risk has decreased by at least 2% absolute value.
Risk of Postoperative Death
Patient Score: 1.2 %
(03/22/22 1200)
Average Risk for Patients Undergoing Similar Surgery: Group Average: 0.8 %
Similar surgery defined as surgical service = ORTHO



System Usability Scale
Mean 82.5 ± 10.5

ACT Timeline



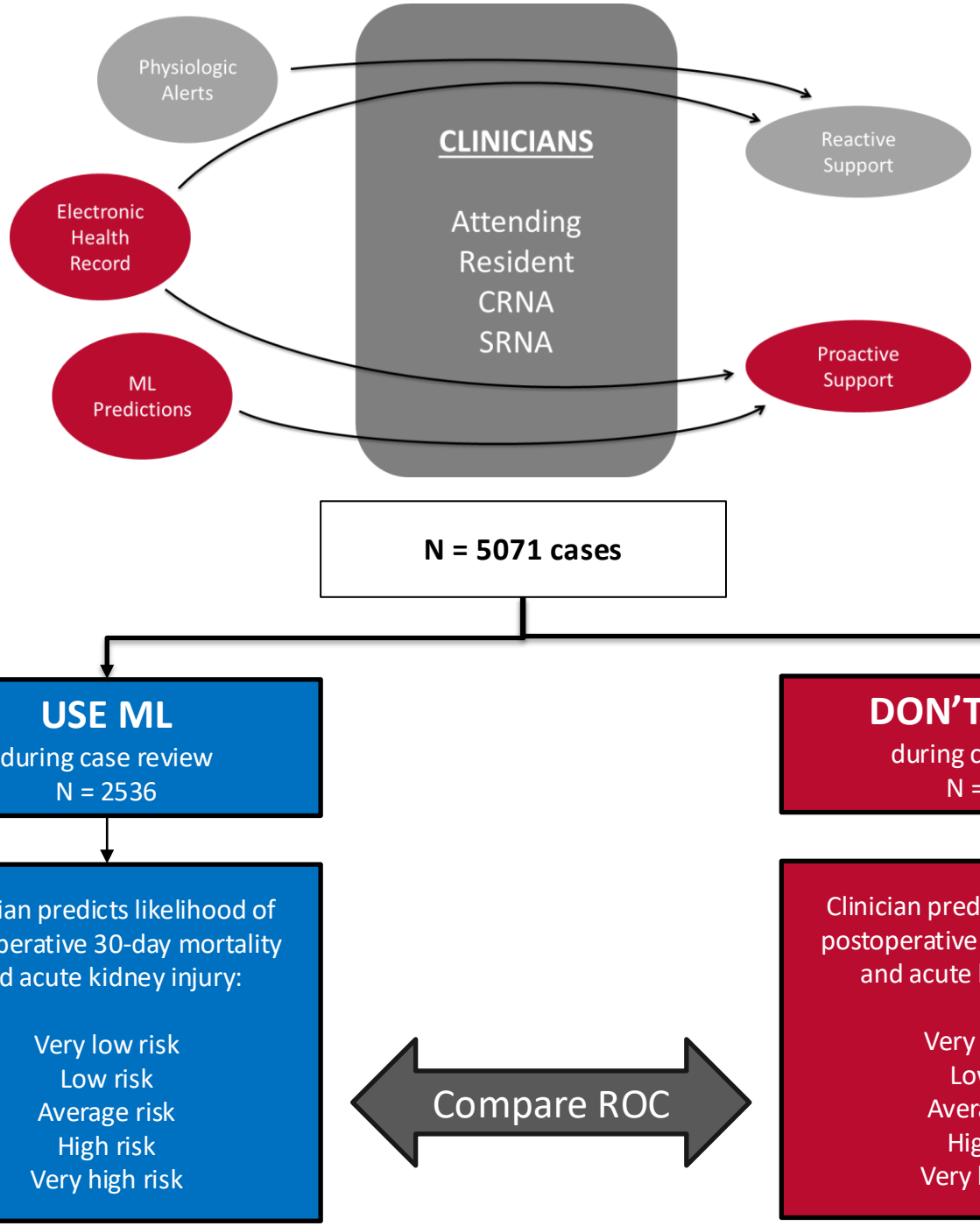
ORACLE

Outcome Risk Assessment with Computer Learning Enhancement


Thaddeus Budelier

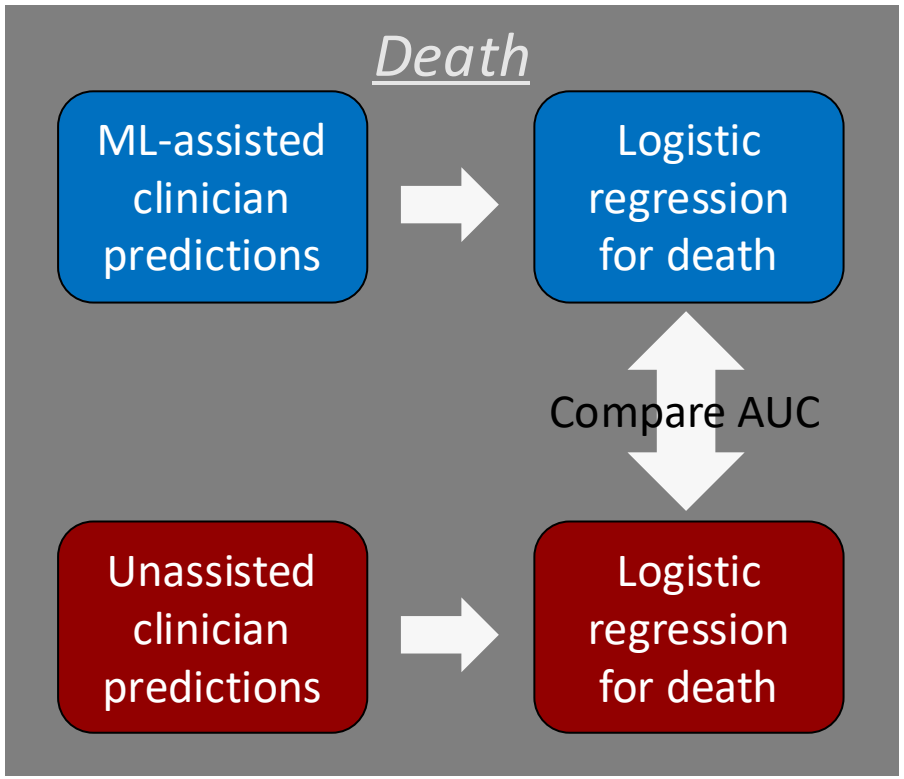

Arianna Montes de Oca

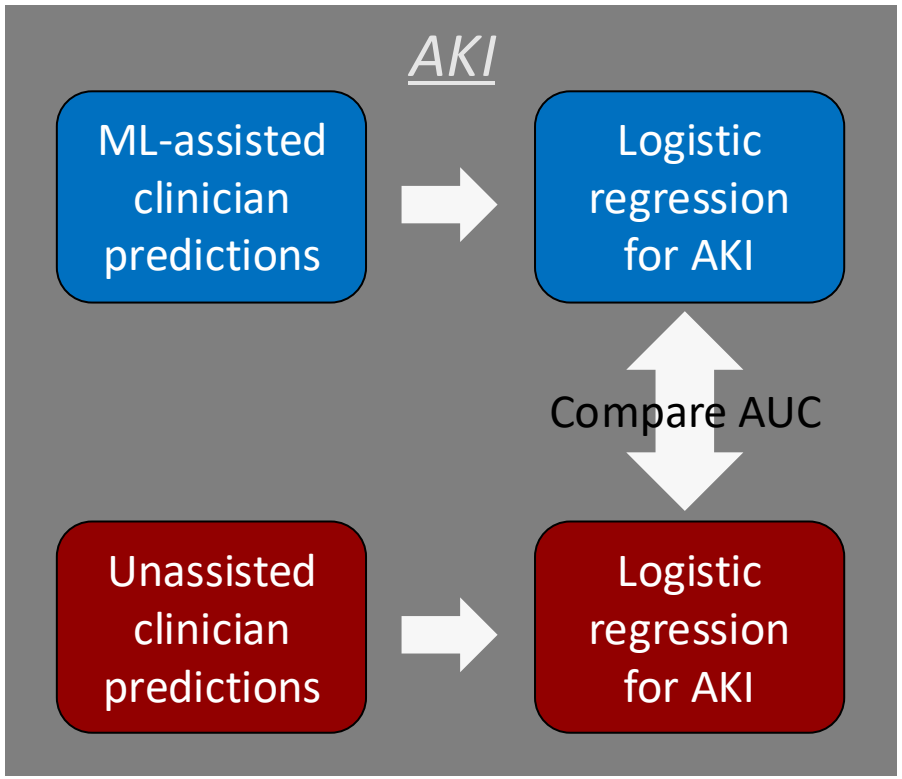

Divya Mehta



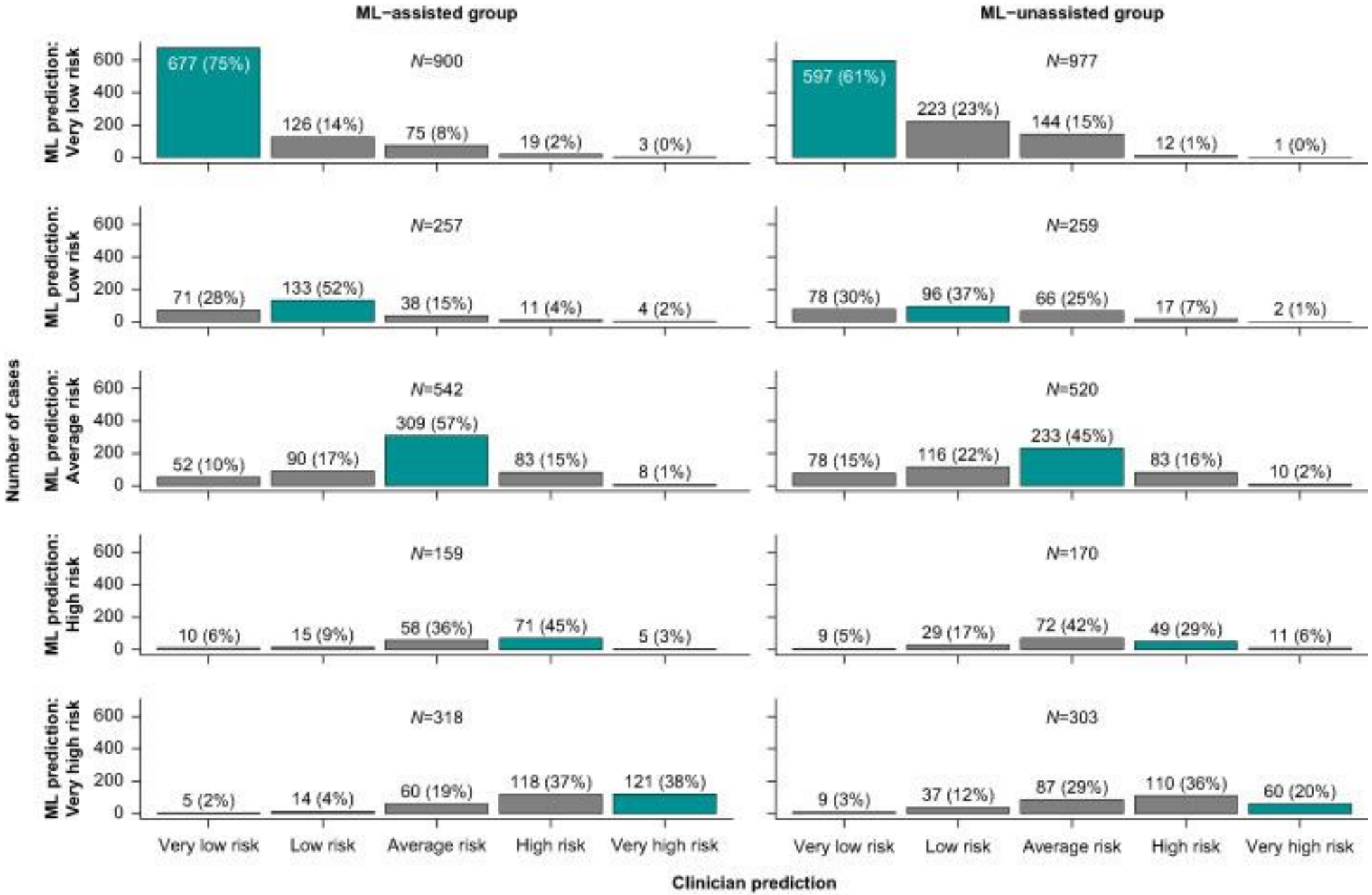
Fritz, et al. Br J Anaest. 2024; 133: 1042-50

Statistical Methods





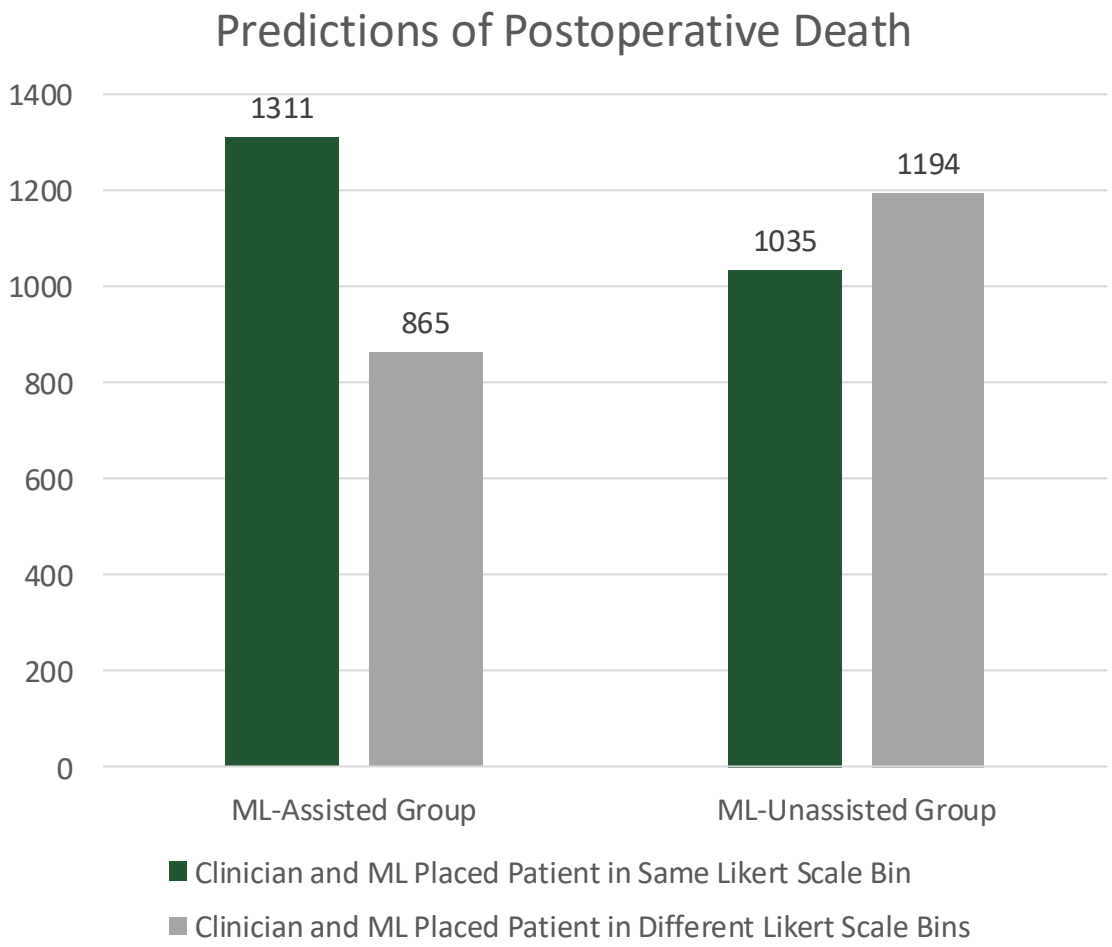
Fritz, et al. Br J Anaest. 2024; 133: 1042-50

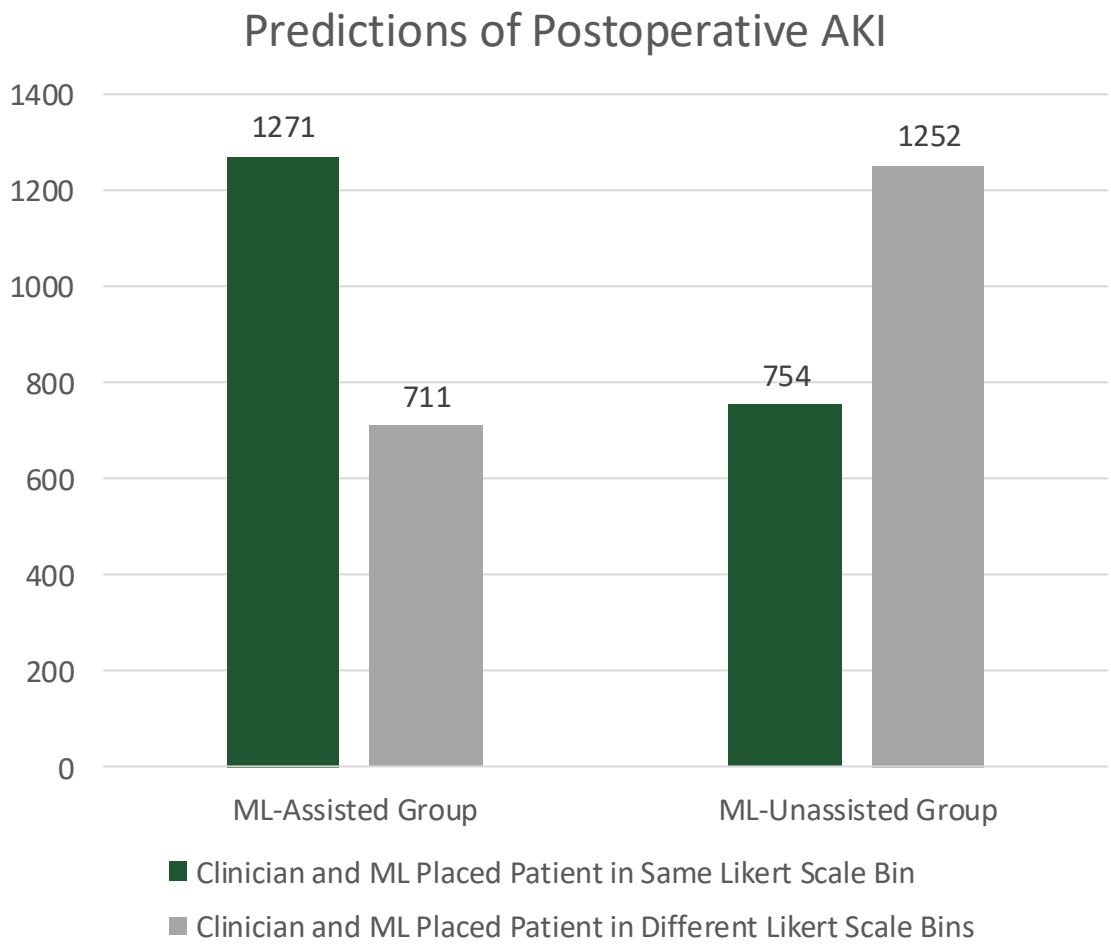


Fritz, et al. Br J Anaest. 2024; 133: 1042-50

ORACLE Trial

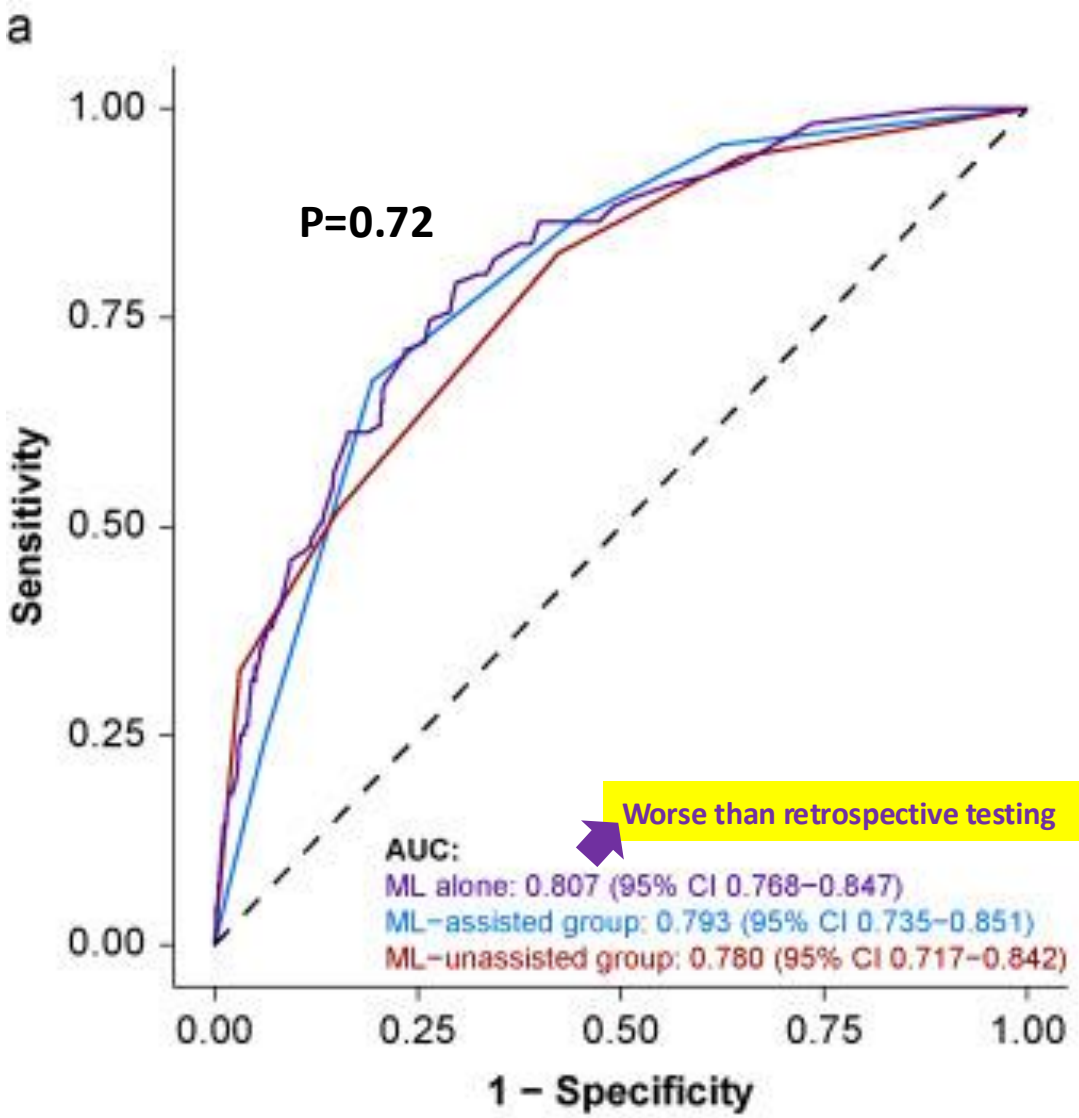
Clinicians used the ML



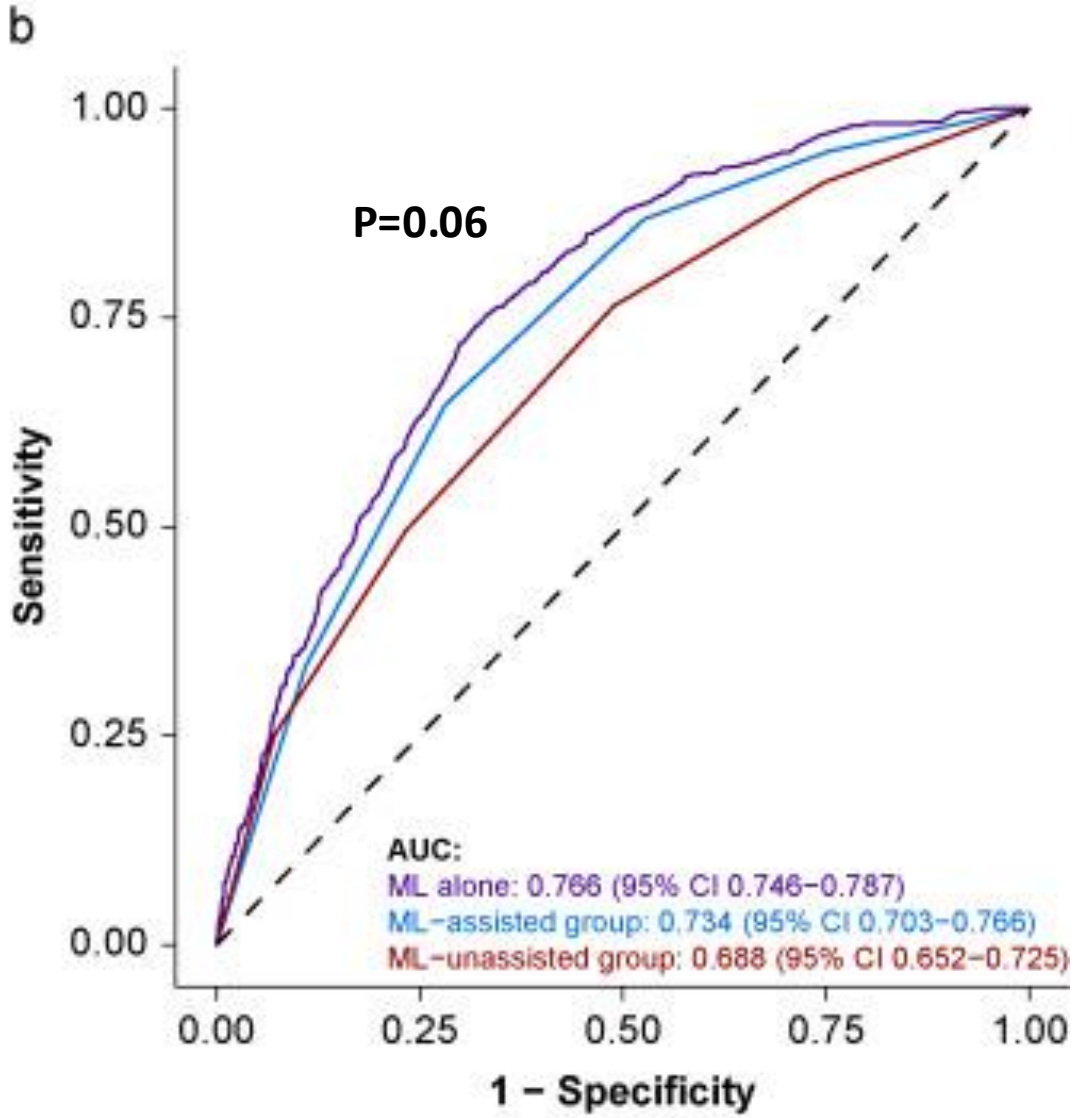


Fritz, et al. Br J Anaest. 2024; 133: 1042-50

DEATH (N = 4459)

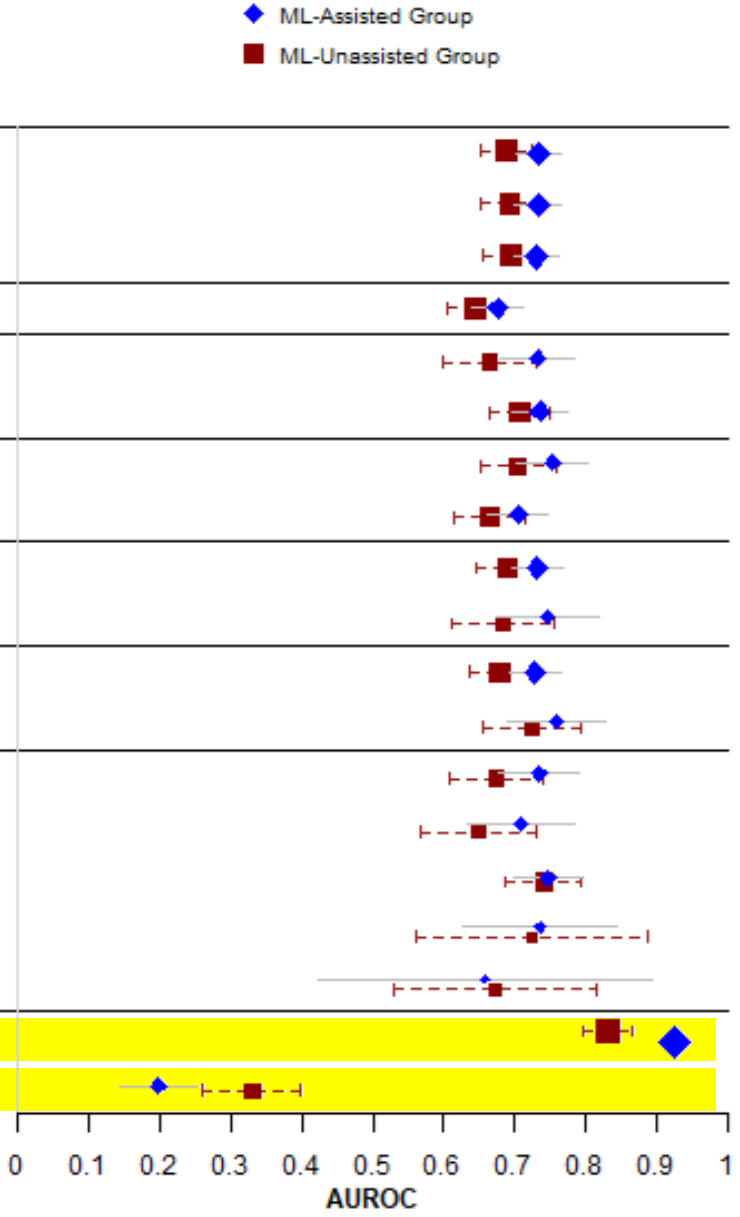


AKI (N = 4055)



Fritz, et al. Br J Anaest. 2024; 133: 1042-50

Analysis	N	ML-Assisted Group AUROC (95% CI)	ML-Unassisted Group AUROC (95% CI)
Intention to Treat	4055	0.734 (0.703-0.766)	0.688 (0.652-0.725)
Per Protocol	3269	0.733 (0.699-0.766)	0.693 (0.653-0.733)
As Treated	3844	0.731 (0.699-0.763)	0.694 (0.657-0.732)
Exclude If No Postoperative Creatinine	2960	0.676 (0.640-0.711)	0.644 (0.605-0.684)
Models Version 1	1443	0.733 (0.682-0.785)	0.665 (0.600-0.730)
Models Version 2	2612	0.736 (0.696-0.775)	0.707 (0.664-0.751)
Female	2179	0.754 (0.704-0.803)	0.705 (0.651-0.759)
Male	1876	0.705 (0.663-0.748)	0.665 (0.614-0.716)
White Race	3171	0.732 (0.697-0.768)	0.691 (0.647-0.735)
Black Race	750	0.746 (0.673-0.819)	0.685 (0.612-0.757)
TECTONICS Telemedicine Group	3269	0.729 (0.693-0.764)	0.679 (0.636-0.722)
TECTONICS Usual Care Group	786	0.759 (0.691-0.827)	0.725 (0.656-0.794)
MD/DO - Attending	1277	0.735 (0.679-0.790)	0.674 (0.608-0.741)
MD/DO - CA3 Resident	955	0.709 (0.633-0.784)	0.649 (0.569-0.730)
MD/DO - Intern Level	1155	0.748 (0.699-0.797)	0.741 (0.688-0.794)
CRNA	448	0.736 (0.627-0.844)	0.725 (0.562-0.887)
SRNA	220	0.659 (0.424-0.894)	0.673 (0.530-0.817)
Correct ML Prediction	2693	0.926 (0.905-0.947)	0.832 (0.798-0.866)
Incorrect ML Prediction	1295	0.198 (0.143-0.253)	0.330 (0.261-0.399)



Fritz, et al. Br J Anaest. 2024; 133: 1042-50

ORACLE - Implications

- ML models can help anesthesiology clinicians identify patients at risk for postoperative complications, only if the models achieve high accuracy

- ML models should be integrated into clinical workflows using simple display interfaces that provide actionable information

- ML models require ongoing evaluation and refinement

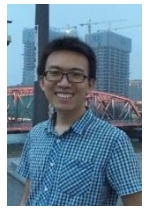






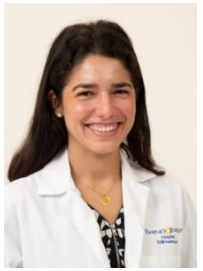




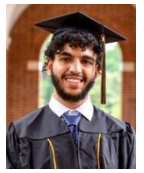







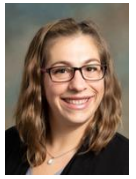










THANK YOU!

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