Postoperative Delirium:

Who's at Risk & How to Predict?

Deborah J. Culley
Harvard Medical School
Brigham & Women's Hospital

Conflicts

R21 AG048522
R56 AG055833
RO1 GM132668

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Risk Factors for Delirium

Patient - Age, pre-existing cognitive impairment, genotype, depression, sensory deficits

Surgical - Ortho, cardiac, major vascular & thoracic, emergency

Medical - Fever, electrolyte abnormalities, AF, Frailty, etc.

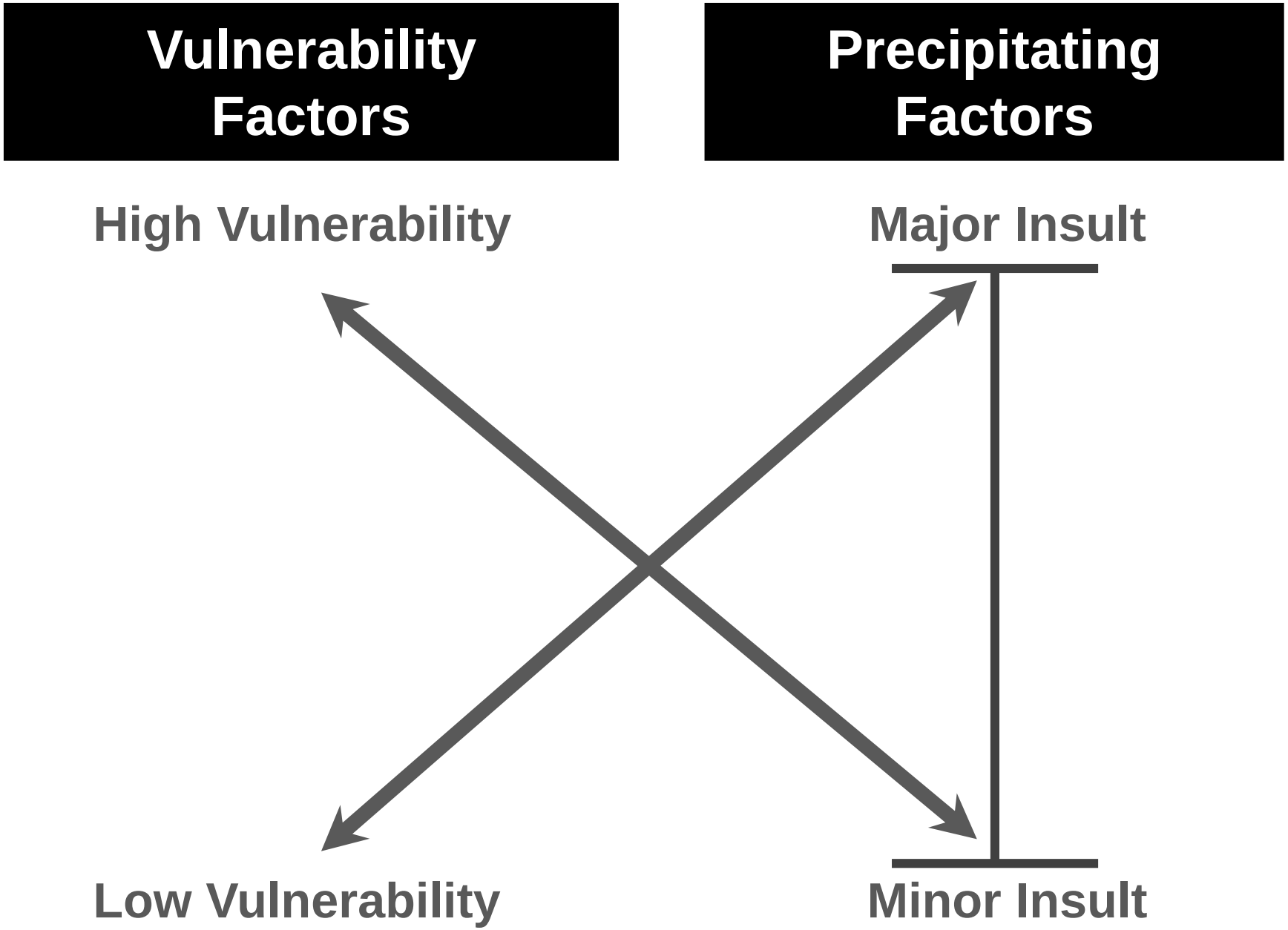
Physiologic - Low SaO2, Hct, albumin

Pharmacology - Medication history; anticholinergics, ketamine, propofol, neuroleptics

J Gen Intern Med. 2018;33:500-509

Risk Factors for Delirium

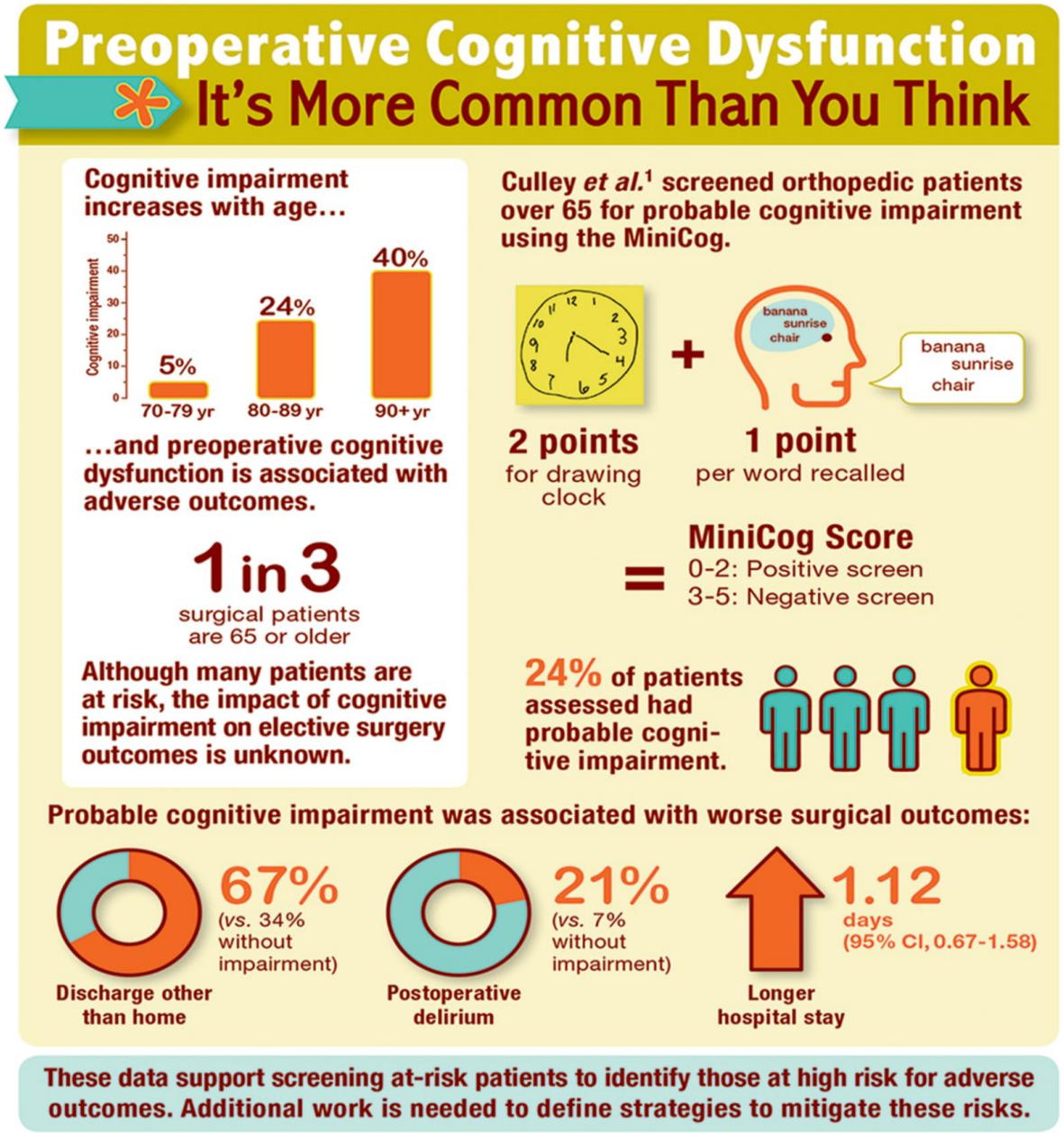
Advanced AGE


Vulnerability Factors
Precipitating Factors
High Vulnerability
Major Insult
Low Vulnerability
Minor Insult

Postoperative Complications in Geriatric Patients

- Liu LL, et al., JAGS 48:405, 2000
- Moller JT, et al. Lancet 351: 857, 1998
- Monk TG, et al., Anesthesiology 108:18, 2008

Complication	Incidence
Pulmonary Embolism	0.5%
ARDS	0.8%
Stroke	1%
Myocardial infarction	2%
Pneumonia	4%
Death	5%
Heart Failure	6%
Delirium	15-60%
POCD	10-12%



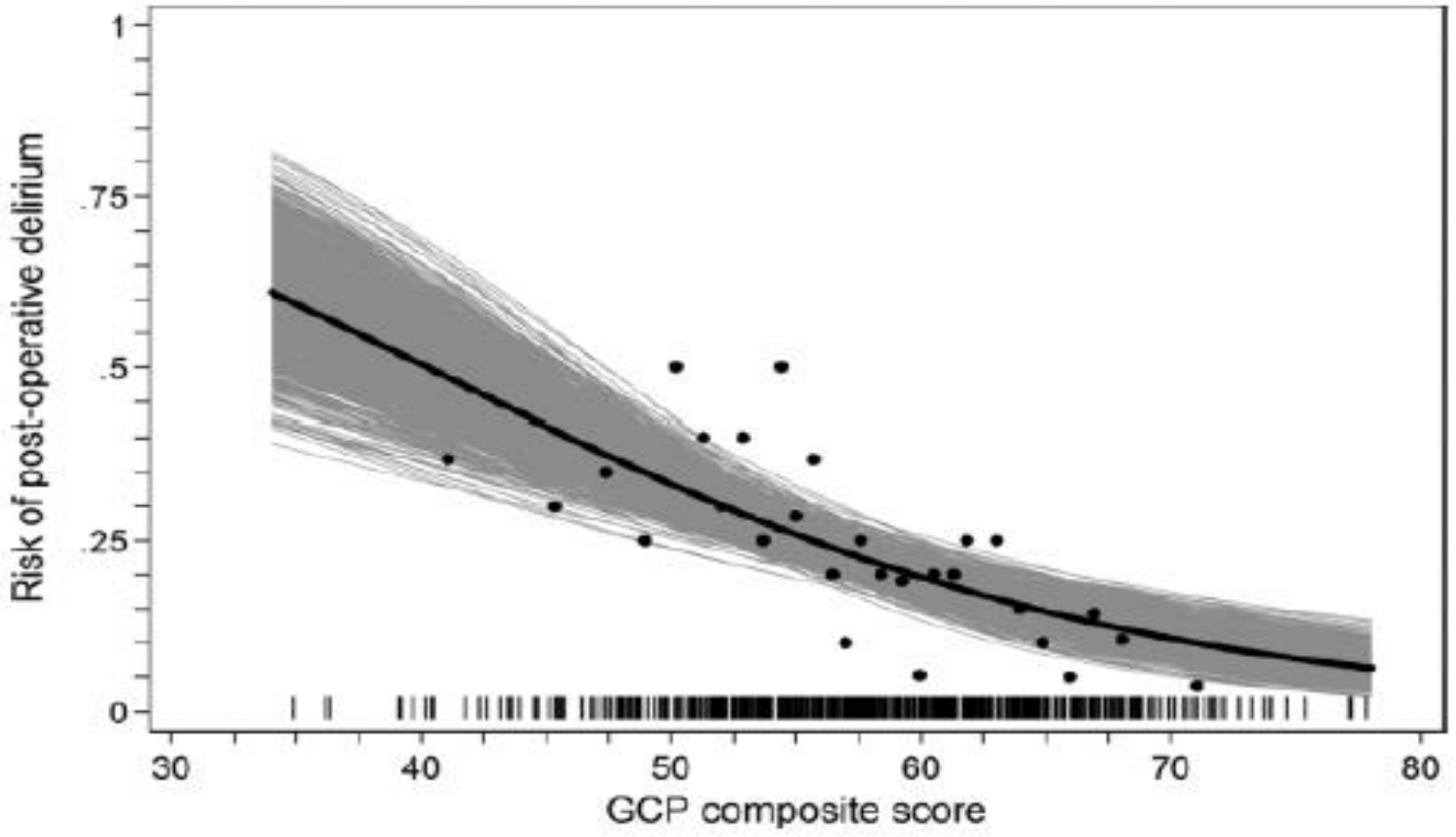
Poor Performance on a Preoperative Cognitive Screening Test Predicts Postoperative Complications in Older Orthopedic Surgical Patients

Deborah J. Culley, M.D., Devon Flaherty, M.D., M.P.H., Margaret C. Fahey, M.A., James L. Rudolph, M.D., Houman Javedan, M.D., Chuan-Chin Huang, Ph.D., John Wright, M.D., Angela M. Bader, M.D., M.P.H., Bradley T. Hyman, M.D., Ph.D., Deborah Blacker, M.D., Sc.D., Gregory Crosby, M.D.

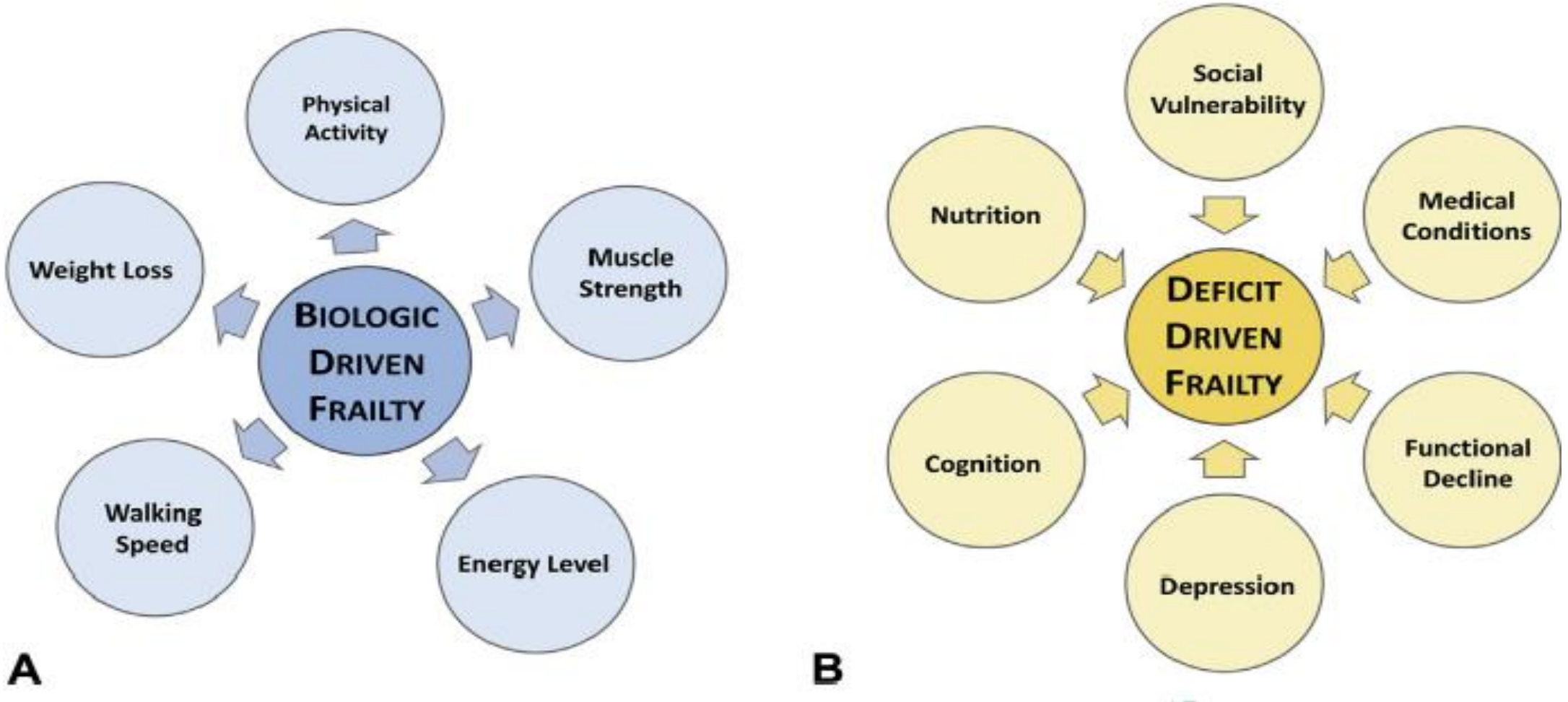
ANESTHESIOLOGY
The Journal of the American Society of Anesthesiologists, Inc.

Anesthesiology. 2017;127:765-774

Preoperative cognition predicts delirium



Jones RN, et al. J Geriatr Psychiatry Neurol 2016; 29:3320-27



Robinson TN, et al., J Am Coll Surg 2015; 221: 1083-92

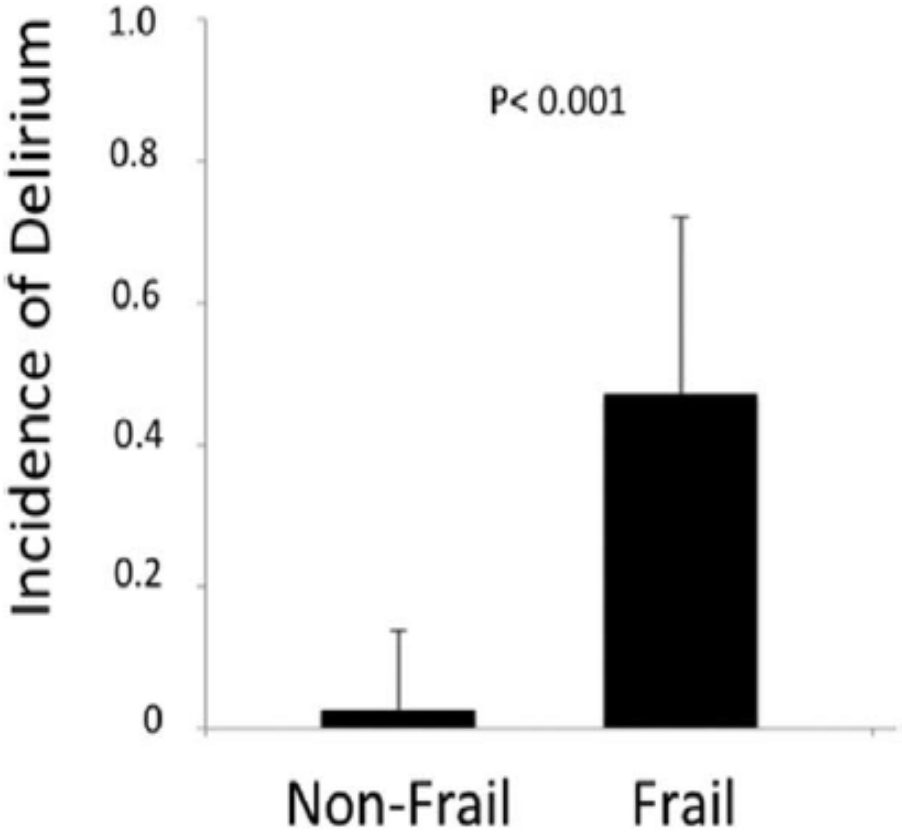
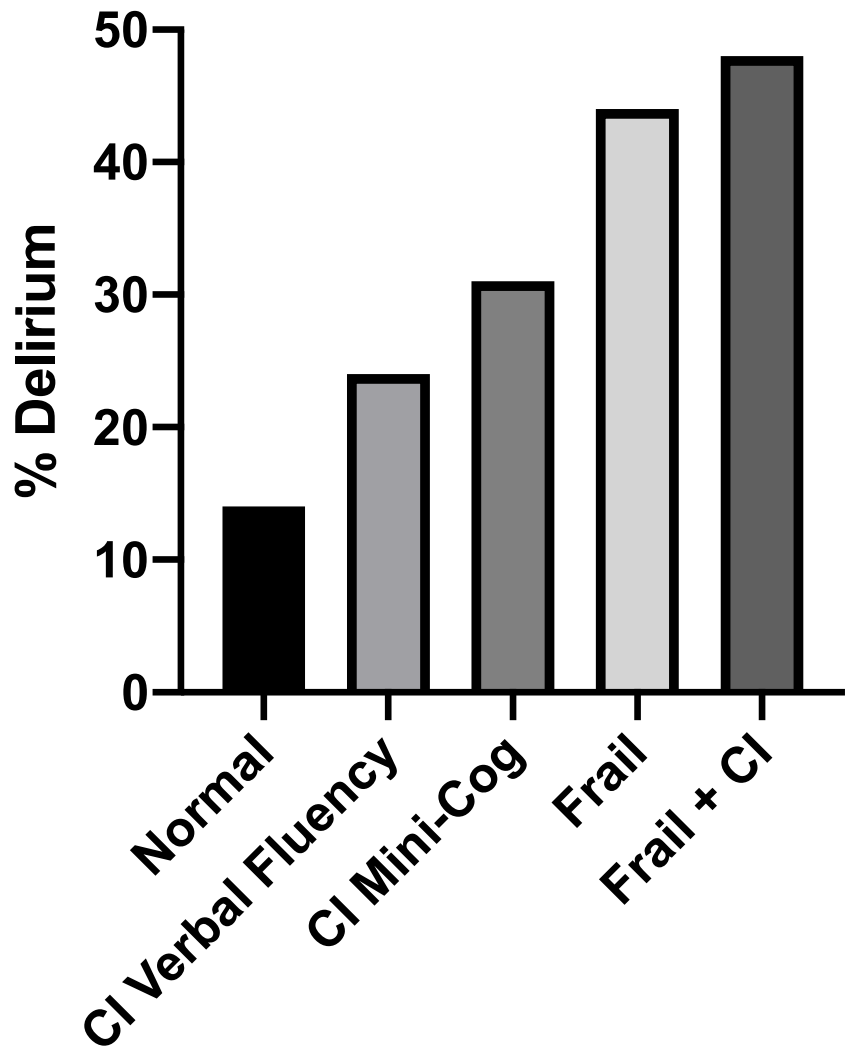


Table 3. Risk of Delirium Among Frail Compared with Nonfrail Patients in Adjusted Models

	Relative risk for delirium[a]	95% CI	*P*
Frailty[b]	18.3	2.1–161.8	0.009
Age (in decades)	1.1	0.5–2.7	0.81
History of stroke	1.8	0.2–17.6	0.61
History of depression	0.67	0.1–5.9	0.72
Quintile of Charlson comorbidity index score	0.96	0.6–1.7	0.89

Brown CH IV, et al. Anesth Analg 2016; 123: 430-35



Brief Preoperative Screening for Frailty and Cognitive Impairment Predicts Delirium Following Spine Surgery

Table 3. Frail Scale: 0 to 5 Minutes[69,70]

F	Fatigue (Are you fatigued?)
R	Resistance (Can you climb 1 flight of stairs?)
A	Ambulation (Can you walk 1 block?)
I	Illnesses (greater than 5)
L	Loss of weight (greater than 5%)

Scoring: 0 = robust; 1 – 2 = pre-frail; ≥ 3 frail.

Susano & Culley, Under Review, JAMA Surgery

79 Days

Optimal Preoperative Assessment of the Geriatric Surgical Patient: A Best Practices Guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society

Warren B Chow, MD, MS, MSHSOR, Ronnie A Rosenthal, MD, MS, FACS, Ryan P Merkow, MD, MSHSOR, Clifford Y Ko, MD, MS, MSHS, FACS, Nestor F Esnaola, MD, MPH, MBA, FACS

Best Practices for Postoperative Brain Health: Recommendations From the Fifth International Perioperative Neurotoxicity Working Group

Miles Berger, MD, PhD,* Katie J. Schenning, MD, MPH,† Charles H. Brown IV, MD, MHS,‡ Stacie G. Deiner, MD,§ Robert A. Whittington, MD,‖ and Roderic G. Eckenhoff, MD,¶ for the Perioperative Neurotoxicity Working Group

But ... Are there things we can do?

Table 3. American Geriatrics Society Clinical Practice Guidelines for the Prevention and Treatment of Postoperative Delirium[a]

Recommendation	Description
Strong: Benefits Clearly Outweigh Risks or Vice Versa	
Multicomponent nonpharmacologic interventions (for prevention)	Delivered by interdisciplinary team for at-risk older adults Includes mobility and walking, avoiding physical restraints, orienting to surroundings, sleep hygiene, adequate oxygen, fluids, and nutrition
Educational programs	Ongoing, provided for health care professionals
Medical evaluation	Identify and manage underlying organic contributors to delirium
Pain management	Should be optimized, preferably with nonopioid medications
Medications to avoid	Any medications associated with precipitating delirium (eg, high-dose opioids, benzodiazepines, antihistamines, dihydropyridines) Cholinesterase inhibitors should not be newly prescribed to prevent or treat postoperative delirium Benzodiazepines should not be used as first-line treatment of delirium-associated agitation Benzodiazepines and antipsychotics should be avoided for treatment of hypoactive delirium
Weak: Evidence in Favor of These Interventions, But Level of Evidence or Potential Risks Limit Strength of Recommendation	
Multicomponent nonpharmacologic interventions (for treatment)	Delivered by interdisciplinary team when older adults are diagnosed with postoperative delirium to improve clinical outcomes
Pain management	Injection of regional anesthetic at the time of surgery and postoperatively to improve pain control with the goal of preventing delirium
Antipsychotics	The use of antipsychotics (haloperidol, risperidone, olanzapine, quetiapine, or ziprasidone) at the lowest effective dose for shortest possible duration may be considered to treat delirious patients who are severely agitated, distressed, or threatening substantial harm to self, others, or both

Oh, ES, et al.
JAMA 2017; 121: 318: 1161-74

Table 4. Multicomponent Nonpharmacologic Approaches to Delirium Prevention

Approach	Description
Orientation and therapeutic activities	Provide lighting, signs, calendars, clocks Reorient the patient to time, place, person, your role Introduce cognitively stimulating activities (eg, reminiscing) Facilitate regular visits from family, friends
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Feeding assistance	Follow general nutrition guidelines and seek advice from dietician as needed Ensure proper fit of dentures
Vision and hearing	Resolve reversible cause of the impairment Ensure working hearing and visual aids are available and used by patients who need them
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Hypoxia protocol	Assess for hypoxia and oxygen saturation
Psychoactive medication protocol	Review medication list for both types and number of medications

Original Investigation | Geriatrics

Performance of Electronic Prediction Rules for Prevalent Delirium at Hospital Admission

Christopher W. Halladay, ScM; Andrea Yevchak Sillner, PhD; James L. Rudolph, MD

Table 3. Comparison of 3 NICE Scores and Delirium Risk in the Derivation and Confirmation Cohorts

Validated Prediction Rule and Delirium Risk (Points)	Derivation		Confirmation	
	No. (%) With Delirium (n = 27 625)	AUROC Curve (95% CI)	No. (%) With Delirium (n = 11 752)	AUROC Curve (95% CI)
eNICE score				
Low (0-2)	75 (1.4)	0.81 (0.80-0.82)	27 (1.0)	0.83 (0.81-0.84)
Intermediate (3-5)	415 (3.5)		136 (2.6)	
High (6-9)	917 (11.9)		344 (11.3)	
Very high (10-18)	936 (38.9)		315 (36.0)	
Pendlebury NICE score				
Low (0-1)	71 (0.6)	0.87 (0.86-0.88)	30 (0.6)	0.87 (0.86-0.88)
Intermediate (2-4)	940 (7.0)		378 (6.8)	
High (5-7)	1332 (41.0)		414 (37.2)	
Consolidated NICE score				
Low (0-2)	252 (1.1)	0.91 (0.91-0.92)	103 (1.1)	0.91 (0.90-0.92)
Intermediate (3-4)	990 (29.4)		371 (27.7)	
High (5-6)	1101 (50.9)		348 (46.5)	

VA Hospital System, 27,625 patients, 98% Male,
76 ± 9 years of age

Delirium Screening Targets:

preexisting cognitive impairment
Infection
sodium level
≥ 80 years or older

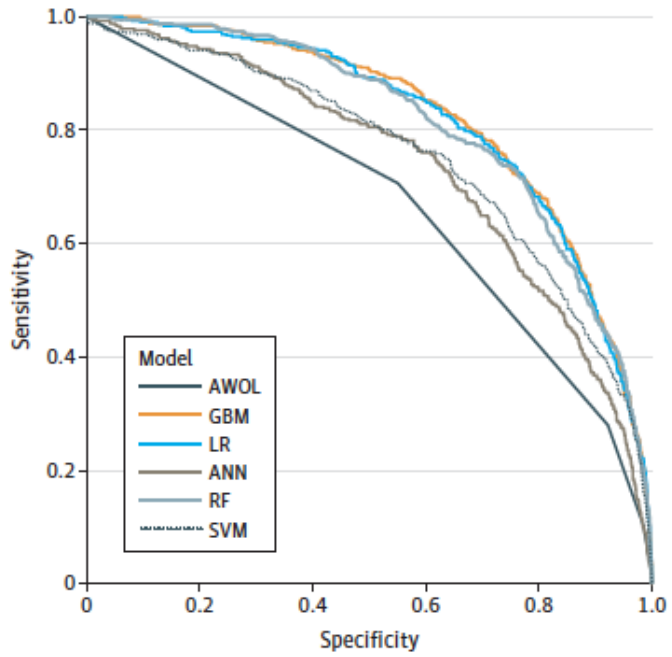
JAMA Netw Open2018;1(4):e181405.

Original Investigation | Health Informatics

Development and Validation of an Electronic Health Record–Based Machine Learning Model to Estimate Delirium Risk in Newly Hospitalized Patients Without Known Cognitive Impairment

Andrew Wong, BA; Albert T. Young, BA; April S. Liang, BSE; Ralph Gonzales, MD, MSPH; Vanja C. Douglas, MD; Dexter Hadley, MD, PhD

Figure 2. Receiver Operating Characteristic Curves for Machine Learning Models and AWOL



Training sample: 14,227
Test set 3,996
≥ 18 years of age

Model performance was evaluated on a prospective test set (receiver operating characteristic curves shown are determined using the subset of the test set with AWOL [age, inability to spell *world* backward, orientation, illness severity] measurements). ANN indicates artificial neural network; GBM, gradient boosting machine; LR, penalized logistic regression; RF, random forest; and SVM, support vector machine.

JAMA Netw Open.2018;1(4):e181018.


MPOG
MULTICENTER PERIOPERATIVE
OUTCOMES GROUP


ASPIRE
Anesthesiolgy Performance
Improvement and Reporting Exchange

Can we use MPOG to identify patients at risk for delirium?

Nationally

State Wide

Regionally

Are there things we can do?

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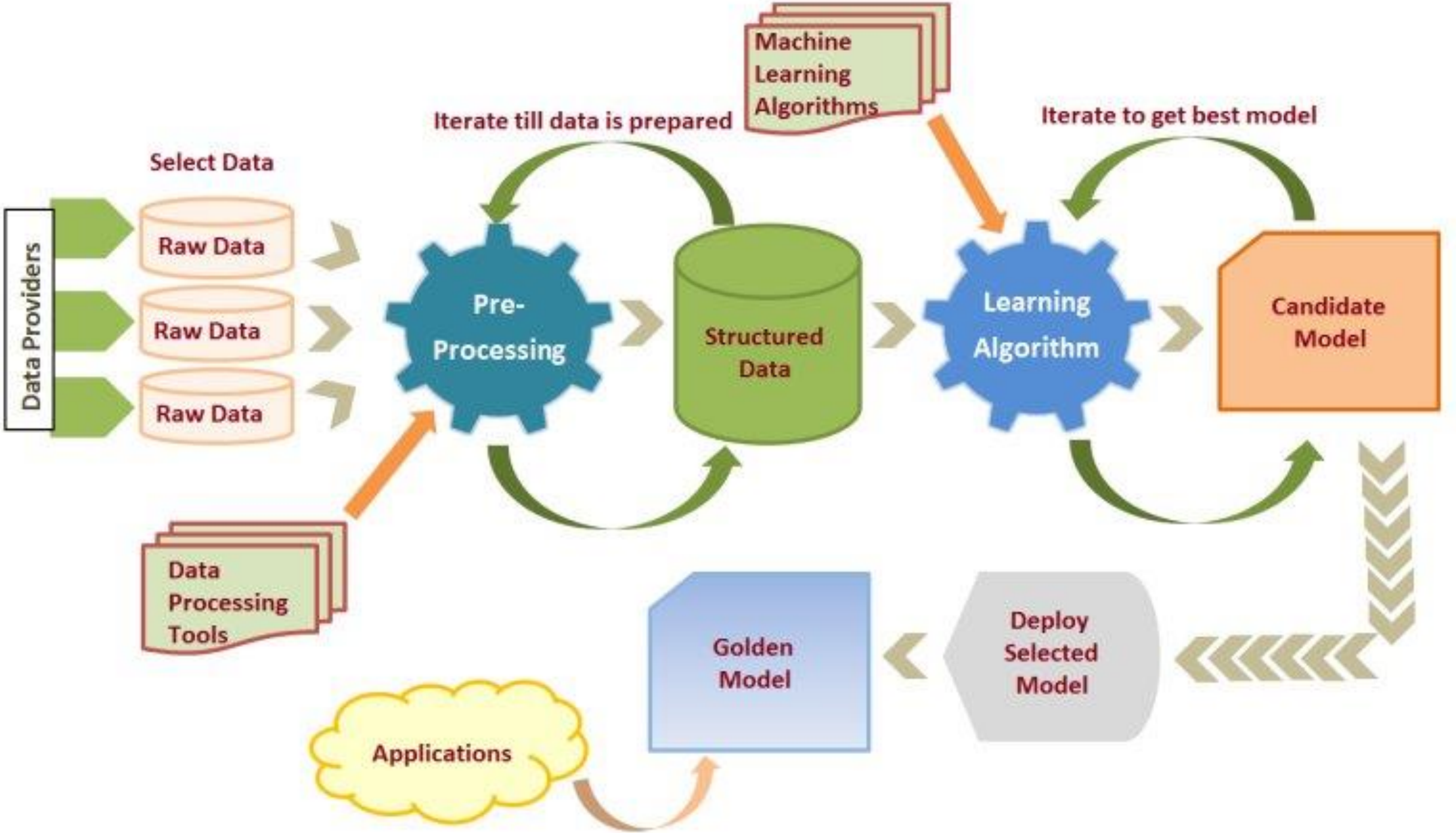
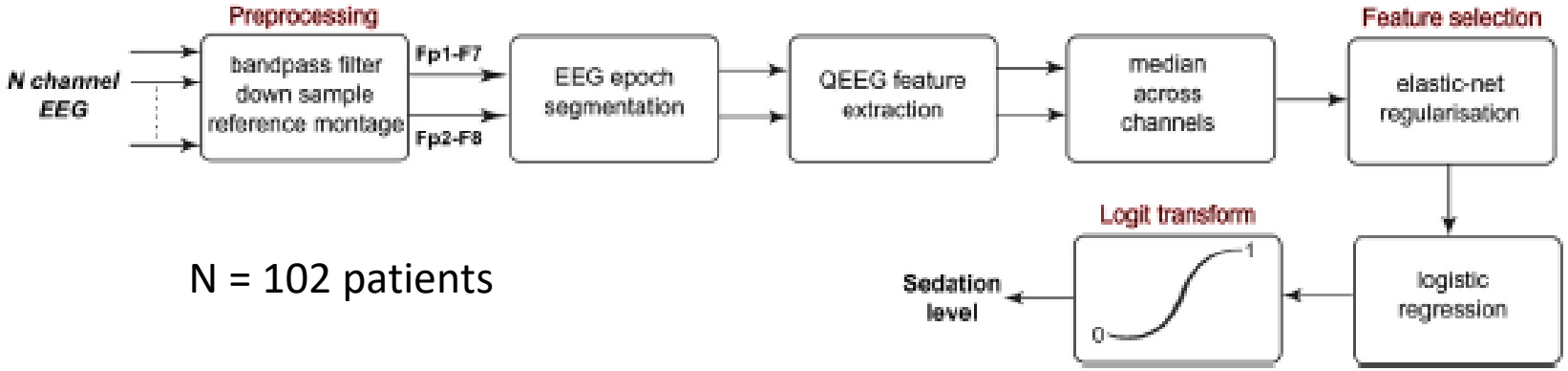

Machine Learning Algorithms
Iterate till data is prepared
Iterate to get best model
Select Data
Data Providers
Raw Data
Raw Data
Raw Data
Pre-Processing
Structured Data
Learning Algorithm
Candidate Model
Data Processing Tools
Golden Model
Deploy Selected Model
Applications

Novel drug-independent sedation level estimation based on machine learning of quantitative frontal electroencephalogram features in healthy volunteers

Sowmya M. Ramaswamy[1,*], Merel H. Kuizenga[1], Maud A. S. Weerink[1], Hugo E. M. Vereecke[1,2], Michel M. R. F. Struys[1,3,†] and Sunil B. Nagaraj[4,†]



N = 102 patients

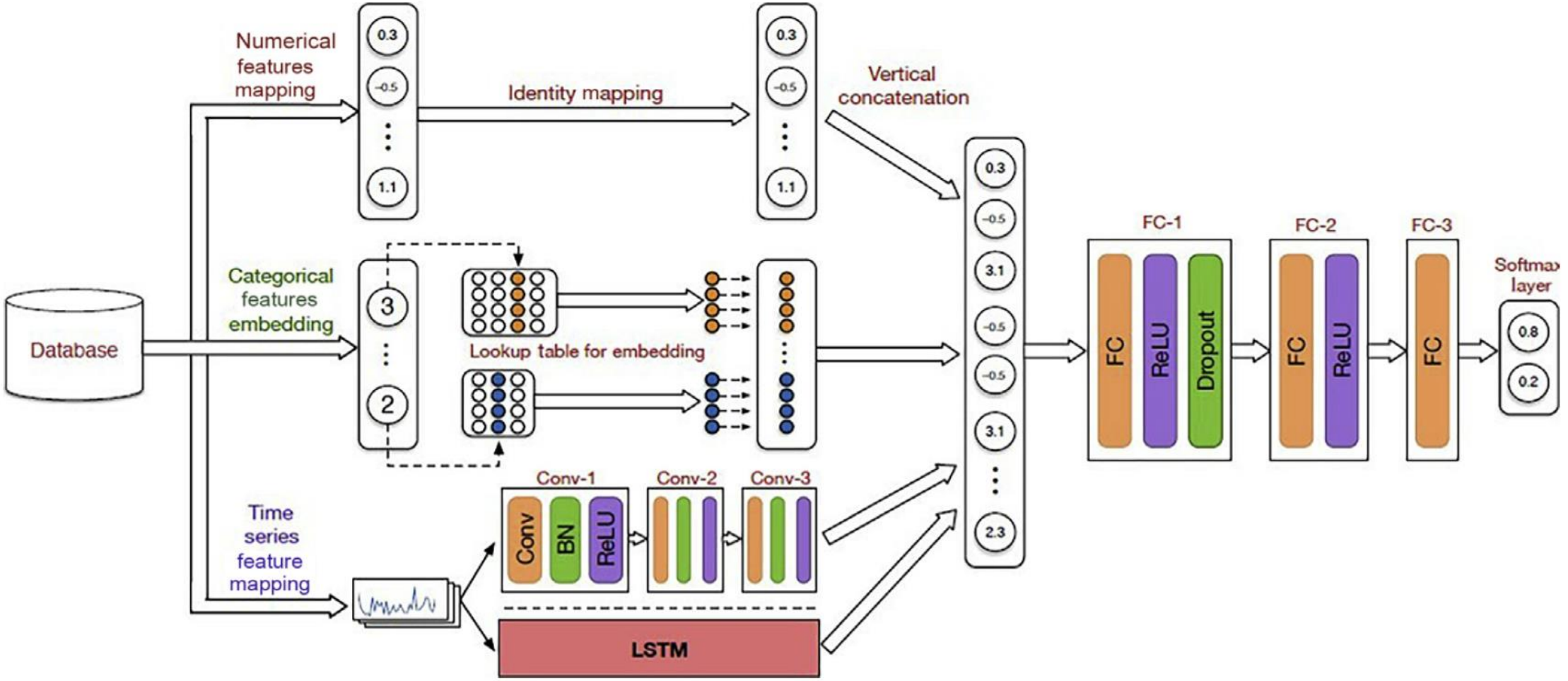
Table 2 Performance of the proposed sedation-level estimator (AUC values across patients) using feature sets. Results are reported as mean (standard deviation). AUC, area under the curve; DD, train and test on dexmedetomidine; DP, train on dexmedetomidine and test on propofol; DS, train on dexmedetomidine and test on sevoflurane; PD, train on propofol and test on dexmedetomidine; PP, train and test on propofol; PS, train on propofol and test on sevoflurane; QEEG, quantitative EEG; SD, train on sevoflurane and test on dexmedetomidine; SP, train on sevoflurane and test on propofol; SS, train and test on sevoflurane.

Feature	PP	SS	DD	SP	DP	PS	DS	PD	SD
Time	0.90 (0.08)	0.67 (0.23)	0.75 (0.09)	0.87 (0.09)	0.87 (0.10)	0.67 (0.21)	0.66 (0.22)	0.73 (0.10)	0.74 (0.09)
Frequency	0.95 (0.06)	0.70 (0.22)	0.75 (0.09)	0.90 (0.07)	0.83 (0.11)	0.70 (0.22)	0.63 (0.20)	0.73 (0.10)	0.68 (0.08)
Entropy	0.96 (0.04)	0.72 (0.23)	0.77 (0.10)	0.95 (0.05)	0.91 (0.07)	0.71 (0.24)	0.67 (0.24)	0.80 (0.09)	0.79 (0.10)
QEEG	0.97 (0.03)	0.74 (0.25)	0.77 (0.10)	0.93 (0.06)	0.82 (0.11)	0.73 (0.23)	0.66 (0.18)	0.79 (0.09)	0.78 (0.10)

Br J Anaesth. 2019;123:479-487

Deep-learning model for predicting 30-day postoperative mortality

Bradley A. Fritz[1,*,†], Zhicheng Cui[2,†], Muhan Zhang[2], Yujie He[2], Yixin Chen[2], Alex Kronzer[1], Arbi Ben Abdallah[1], Christopher R. King[1] and Michael S. Avidan[1]



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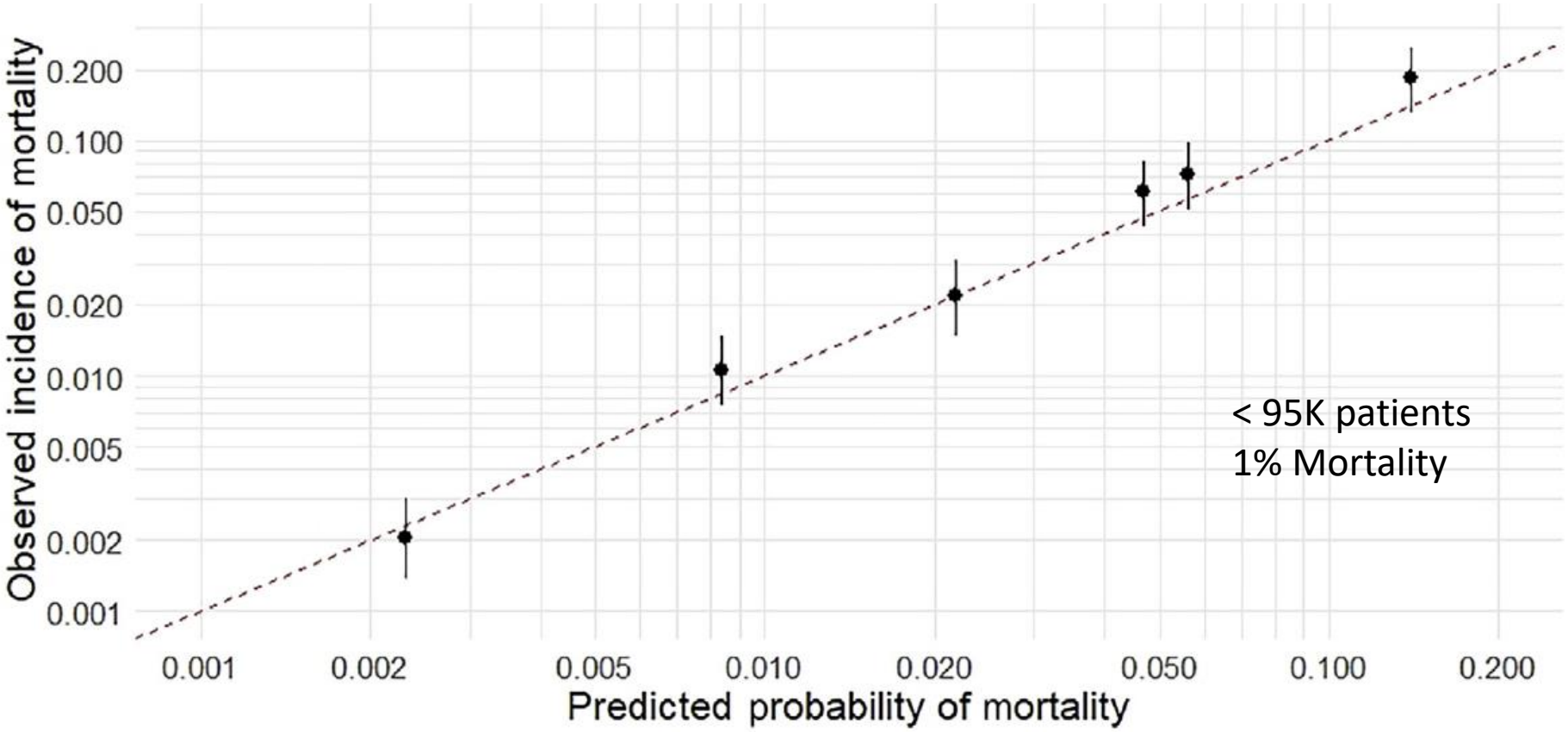

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Table 3 Performance of multipath convolutional neural network model (MPCNN) compared with deep neural network (DNN) without time series, random forest (RF), support vector machine (SVM), and logistic regression (LR). Both the long short-term memory (LSTM) and convolution neural network (CNN) methods of handling time-series data are presented. AUPRC, area under precision–recall curve; AUROC, area under the receiver operating characteristic curve; CI, confidence interval.

Model	AUROC (95% CI)	AUPRC (95% CI)
MPCNN–LSTM	0.867 (0.835–0.899)	0.095 (0.085–0.109)
MPCNN–CNN	0.855 (0.822–0.887)	0.089 (0.077–0.100)
DNN	0.825 (0.790–0.856)	0.078 (0.068–0.088)
RF	0.848 (0.815–0.882)	0.078 (0.067–0.088)
SVM	0.836 (0.802–0.870)	0.072 (0.062–0.081)
LR	0.837 (0.803–0.871)	0.085 (0.074–0.096)

Br J Anaesth. 2019

Can we do this for delirium?

- It will likely be more difficult
  - Prior examples had end firm end points
    - 30-day Postoperative Mortality in a Large Number of Patients
    - Sedations Scores in All Patients
  - Predictors may be in the electronic record
  - Diagnosis of delirium is less likely to be accurate in the medical record
  - This would require a commitment to screen a large number of people for delirium for the Machine Learning and Validation
- It is worth doing …
  -

Are there things we can do?

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Informed Consent
Patient and Family Centered Care

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Could you imagine a world where you could predict the number one cause of postoperative morbidity in older surgical patients with an AUC of 0.8?

We have the opportunity to reduce the risk by up to 40%!

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QI ACTIVITY CATEGORIES		POINTS/ HOUR	MAX POINTS IN 5 YEARS	REPORT YOUR ACTIVITIES
MOCA simulation course	ASA-endorsed simulation center	3	20	Provider reports for you
Course follow-up materials			5	
Other on-site simulation course		1	15	Provider reports for you
Online simulation		1	25	Varies by provider
Other ABMS Member Board Part 4 Activities		1	25	Self-report
Institutional/departmental quality improvement project leader		1	25	Self-report *See the Guide*
Quality improvement plan based on feedback		1	25	Self-report *See the Guide*
Clinical pathway development leader		1	25	Self-report *See the Guide*
Clinical pathway development participant		1	15	Self-report *See the Guide*
ABMS Multi-Specialty Portfolio Program leader		1	25	Organization reports for you
ABMS Multi-Specialty Portfolio Program participant		1	20	Organization reports for you
Multicenter Perioperative Outcomes Group (MPOG): ASPIRE provider feedback emails		1	25	Organization reports for you
Case evaluation or M&M/case discussion or practice improvement CME		1	15	Self-report *See the Guide*
Point-of-care learning *(Minimum of one hour/case; Report within 31 days of case)*		1	15	Self-report *See the Guide*
AQI NACOR: Measure Review and Quality Improvement Action Plan		1	25	Organization reports for you

MPOG: ASPIRE Provider Feedback Emails

Description	Diplomates who practice at an active MPOG (Multicenter Perioperative Outcomes Group) site can receive a monthly performance feedback email from ASPIRE. They'll review their personal performance on ASPIRE quality measures to direct practice improvements. Learn how to become an MPOG member.
Point Value	1 point per hour spent on the activity up to 25 points
Reporting Mechanism	MPOG will report completion to us.

Thank You!

http://www.asahq.org/brainhealthinitiative#news