



ABC-study

Appropriate use of Blood Cultures in the emergency department through machine learning: a randomized controlled trial

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ABC-study (English)





Bacteremia



~20% of ED visits are infection related



Bacteremia = bacteria found in blood = blood stream infection (BSI)

Blood stream infection → high mortality



Very low threshold for taking blood cultures



Blood culture

- 7,5-15% positive
 - Almost 50% contaminated
 - Rarely influence treatment decisions
- “No harm in trying..”
- Longer time in hospital, longer treatment, increased diagnostics, and even higher rates of complications



Appropriate use of Blood Cultures

BMJ Open Using machine learning to predict blood culture outcomes in the emergency department: a single-centre, retrospective, observational study

Anneroos W Boerman,^{1,2} Michiel Schinkel,^{1,3} Lotta Meijerink,⁴ Eva S van den Ende,¹ Lara CA Pladet,¹ Martijn G Scholtemeijer,⁴ Joost Zeeuw,⁴ Anuschka Y van der Zaag,¹ Tanca C Minderhoud,¹ Paul W G Elbers,⁵ W Joost Wiersinga,^{3,6} Robert de Jonge,² Mark HH Kramer,⁷ Prabath W B Nanayakkara ¹

Diagnostic stewardship for blood cultures in the emergency department: A multicenter validation and prospective evaluation of a machine learning prediction tool

Michiel Schinkel,^{a,b,1} Anneroos W. Boerman,^{a,c,1} Frank C. Bennis,^d Tanca C. Minderhoud,^a Mei Lie,^{e,f} Hessel Peters-Sengers,^b Frits Holleman,^g Rogier P. Schade,^h Robert de Jonge,^c W. Joost Wiersinga,^{b,i} and Prabath W.B. Nanayakkara ^{a*}



Methode

- Patients 18+, blood culture taken on ED
- Available data from EHR
- Outcome positive vs. negative (including contamination) blood cultures
- eXtreme Gradient Boosting (XG Boost) model



Methode - variables



Age



Gender



Vital parameters



Lab results



Methode - data



Age



Gender



Vital parameters



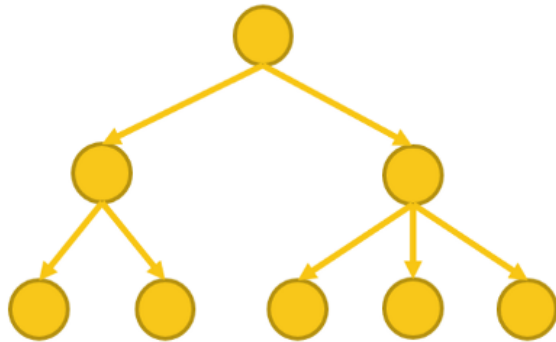
Lab results

- Location VUmc:
 - 2016 - 2021
 - Training and test set
- External validation:
 - AMC: 2020 -2021
 - ZMC: 2016 - 2021
 - BIDMC: 2011 - 2019
 - Treant: 2016 - 2020



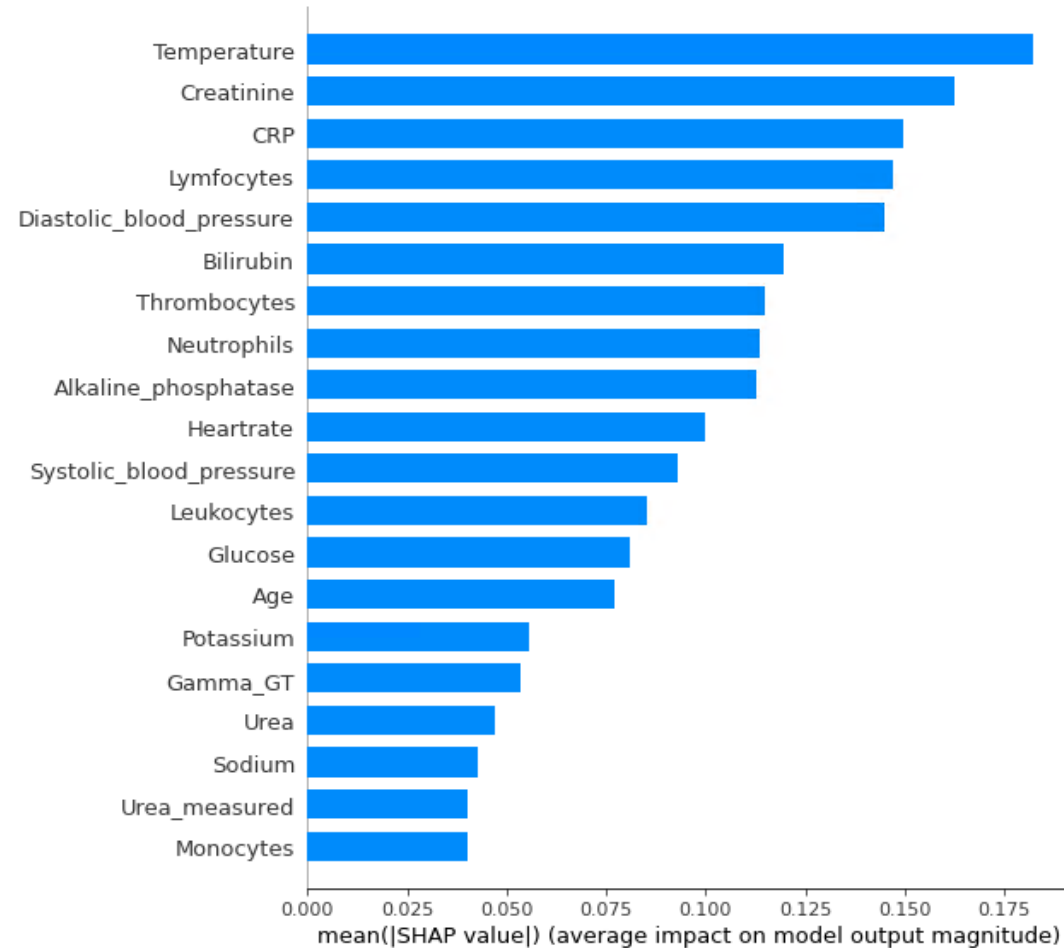
Algorithm

Single Decision Tree





Results - predictors





Results - population

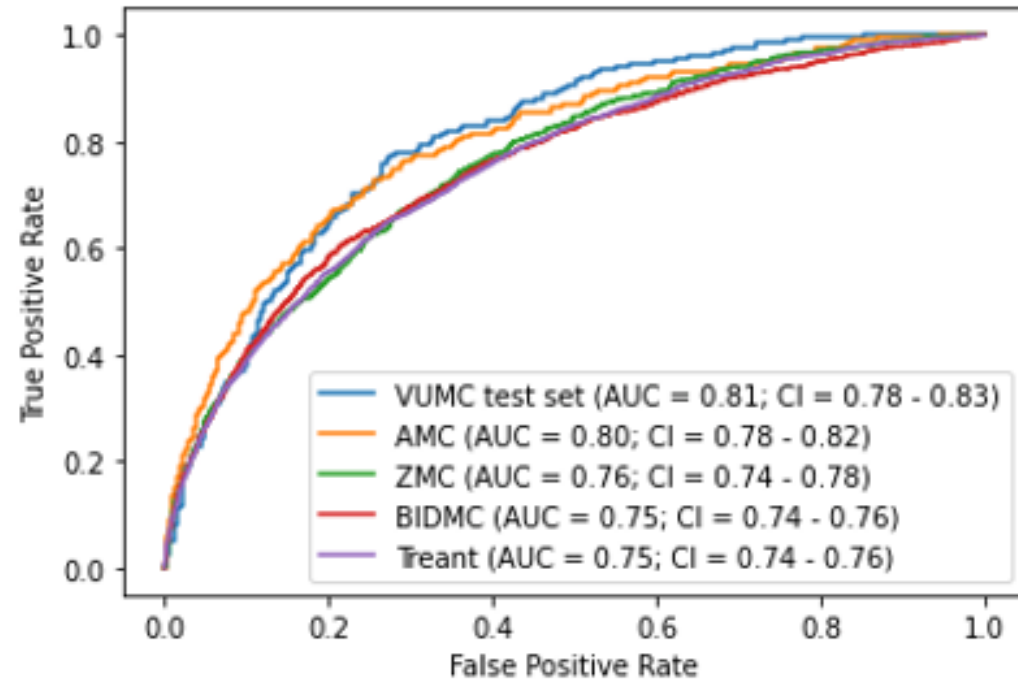
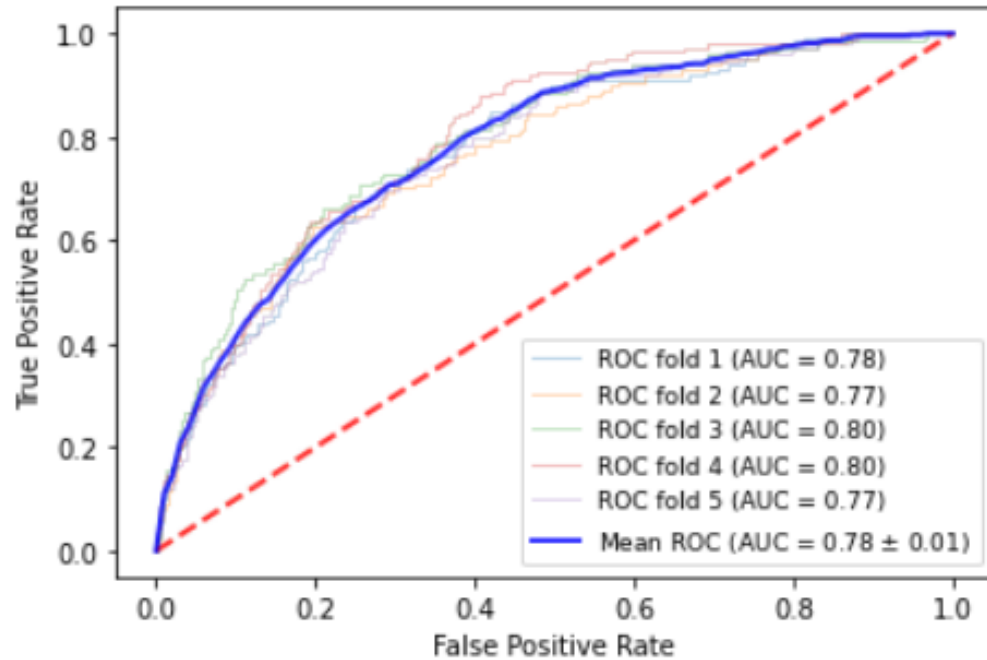
Table 1. Cohort descriptions of predictor variables and outcomes in the datasets used to develop and validate the machine learning model to predict blood culture outcomes in the emergency department.

Variable	VUMC training (n=6.421)	VUMC test (n=1.606)	AMC (n=2.429)	ZMC (n=4.836)	BIDMC (n=27.706)	Treant (n=16.673)
Age, median, y (IQR)	66 (52-76)	66 (53-76)	62 (48-73)	71 (58-81)	61 (49-73)	71 (58-79)
Sex, Female, n (%)	3666 (43.2%)	896 (44.2%)	1134 (46.7%)	2263 (46.8%)	14075 (50.8%)	7473 (44.3%)
Vital signs, median (IQR)						
Temperature, Celsius	37.7 (36.9-38.5)	37.8 (36.9-38.5)	37.0 (36.3-37.7)	37.4 (36.6-38.3)	36.8 (36.6-37.1)	38.1 (37.4-38.7)
Heart rate, /min	94 (81-106)	93 (81-105)	90 (78-102)	95 (82-108)	85 (74-96)	93 (81-105)
Systolic blood pressure, mmHg	124 (110-140)	123 (110-140)	128 (113-144)	125 (110-141)	125 (112-139)	136 (120-152)
Diastolic blood pressure, mmHg	74 (66-83)	74 (65-83)	76 (67-85)	76 (65-86)	70 (62-78)	76 (66-86)
Respiratory rate, /min	20 (16-25)	20 (16-25)	20 (16-24)	20 (16-25)	18 (16-19)	20 (17-25)
Saturation, %	96 (95-98)	96 (94-98)	97 (95-98)	96 (94-98)	98 (96-99)	96 (95-98)
Laboratory results, median (IQR)						
C-Reactive Protein	63 (21-141)	58 (19-142)	46 (12-115)	69 (24-156)	48 (11-113)	75 (26-158)
Creatinine	85 (66-119)	84 (65-116)	88 (69-129)	85 (67-113)	88 (62-133)	84 (67-112)
Leukocytes	10.4 (7.0-14.5)	10.3 (6.9-14.5)	9.1 (6.2-13.1)	10.7 (7.4-15.1)	9.3 (6.6-12.9)	11.6 (8.1-15.8)
Outcome						
Positive blood cultures, %	11.5	11.5	11.2	13.5	5.4	13.2
Contaminated cultures, %	6.3	6.3	10.6	5.9	4.9	6.1

IQR = Interquartile Range; VUMC = VU Medical Center; AMC = Academic Medical Center; ZMC = Zaanse Medical Center; BIDMC = Beth Israel Deaconess Medical Center.

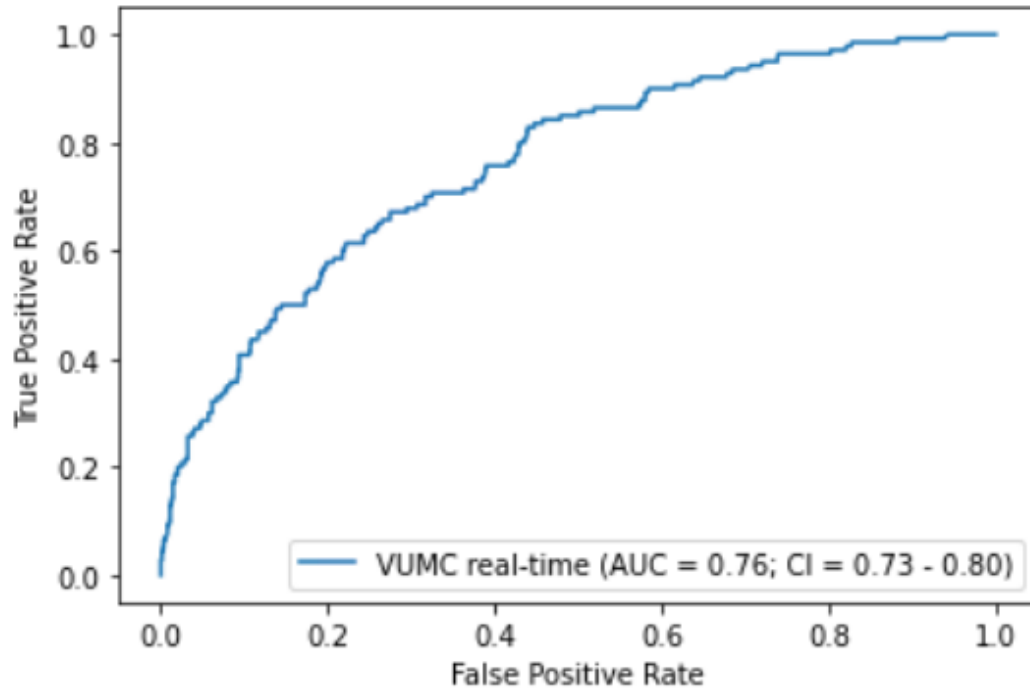


Results





Prospective evaluation (n=1036)



Threshold 5%



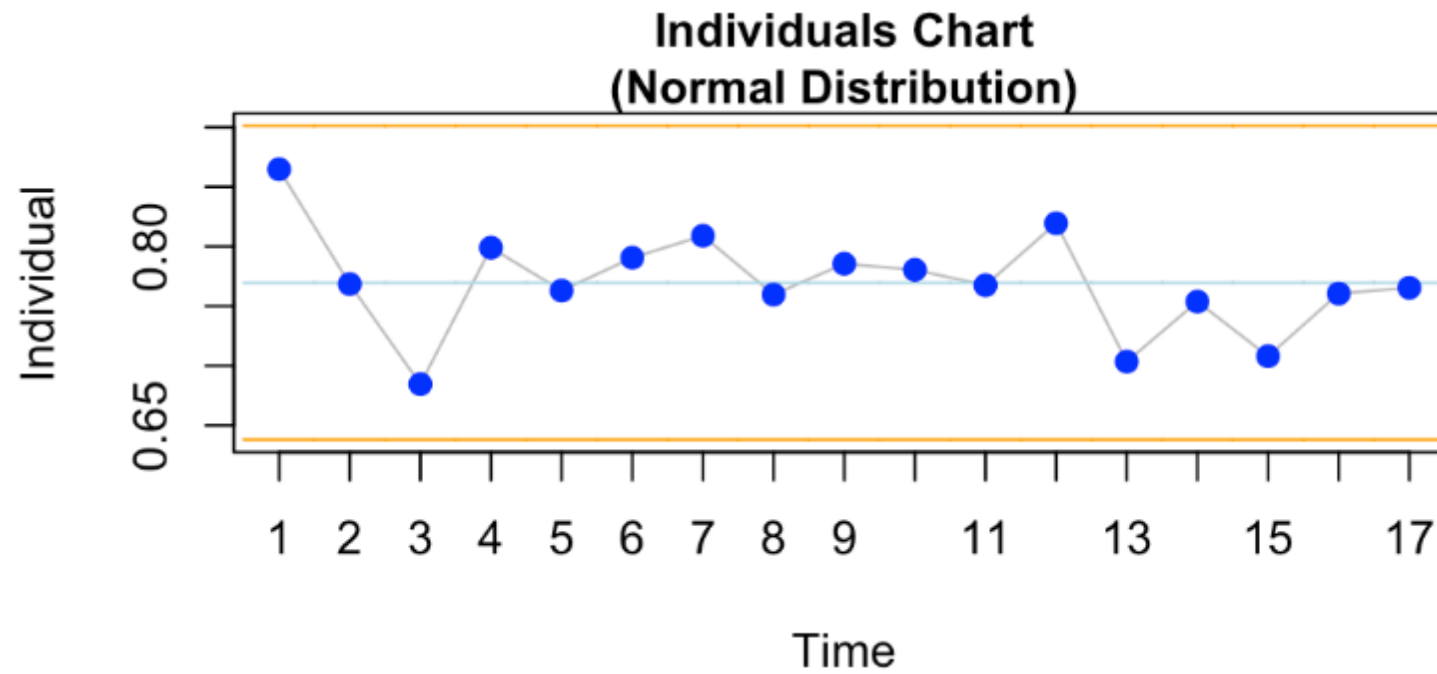
4 missed positive blood cultures (4/303; ~1%)

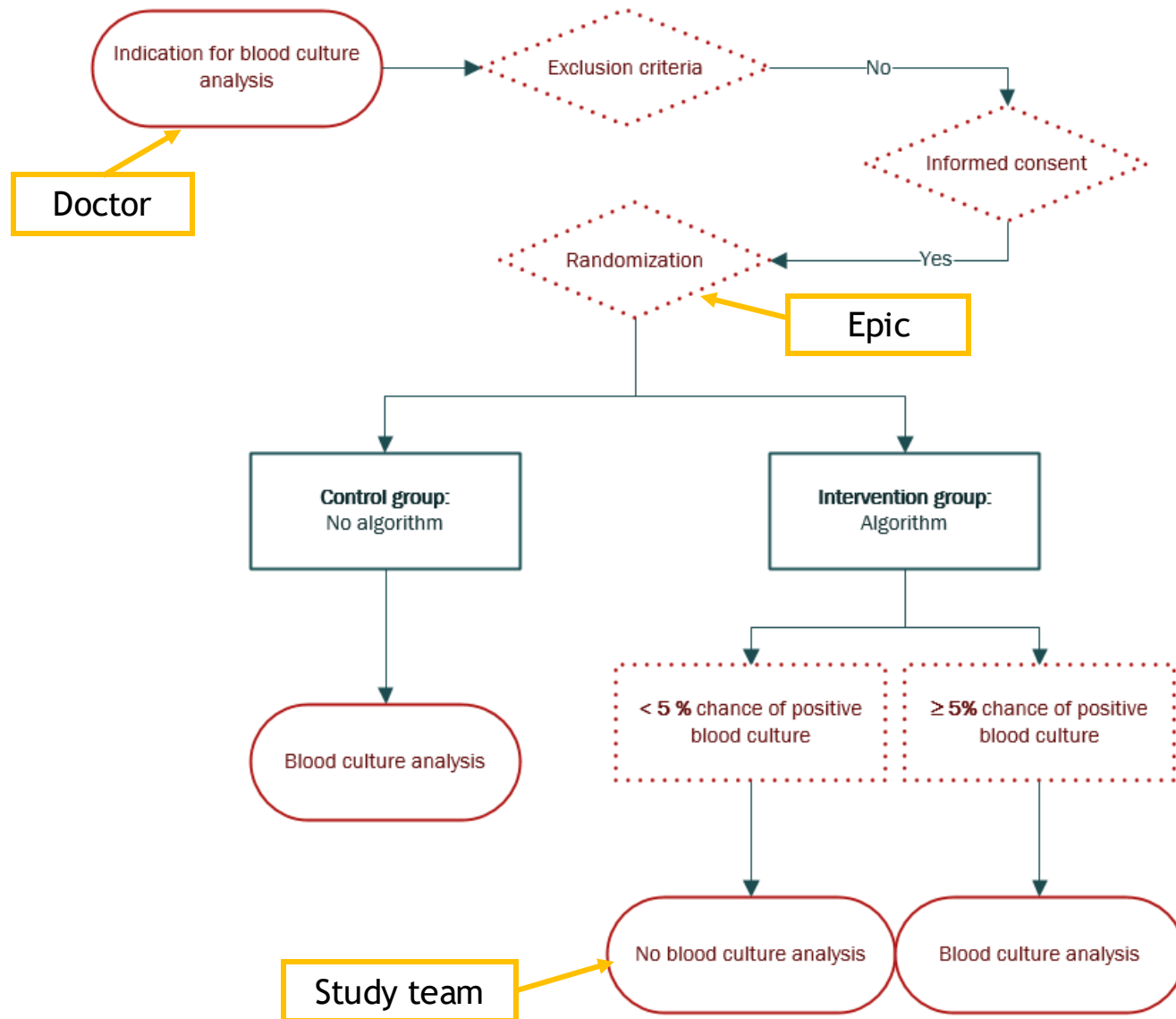


303 visits with blood cultures prevented (303 / 1036; ~29%)



Over time





Flowchart ABC study: Appropriate use of Blood Cultures

Exclusion criteria

- Age < 18 years
- Central Venous Cathether (CVC) or Peripherally Inserted Central Catheter (PICC)
- Neutrophils < $0.5 \times 10^9/L$
- Candidemia / S. Aureus bacteremia in the last 3 months
- Suspected diagnosis of:
 - Endocarditis
 - Spondylodiscitis
 - Infected prosthetic material
- Pregnant or breastfeeding patients
- Not capable of giving informed consent



Outcome measures

Design: randomized controlled non-inferiority trial

Non-inferiority:

- **Primary outcome:**
 - **30-day mortality**
- Secondary outcomes:
 - Admission rate
 - In-hospital mortality
 - Length of stay

Other outcomes:

- Diagnostics:
 - (additional) Diagnostics in ED and during admission
- Treatment:
 - Antibiotics use in ED and during admission
- Algorithm:
 - Performance and improvement (novel biomarkers, NLP, ..)



Integration in EPIC

SEH bloedkweken model

① Score niet voor medisch gebruik. Model is in status validatie.

4,83%

Wel ordenen: 5 - 100
Niet ordenen: 0 - 5

Omschrijving

Het SEH bloedkweken model voorspelt de kans (%) op een positieve bloedkweek. De voorspelling is met name gebaseerd op de vitale gegevens (temperatuur, bloeddruk, ademfrequentie, etc.) en algemene laboratorium uitslagen (CRP, leukocyten, bilirubine, etc.) van de patient gedurende dit SEH bezoek.

SEH bloedkweken model

① Score niet voor medisch gebruik. Model is in status validatie.

9,05%

Wel ordenen: 5 - 100
Niet ordenen: 0 - 5

Omschrijving

Het SEH bloedkweken model voorspelt de kans (%) op een positieve bloedkweek. De voorspelling is met name gebaseerd op de vitale gegevens (temperatuur, bloeddruk, ademfrequentie, etc.) en algemene laboratorium uitslagen (CRP, leukocyten, bilirubine, etc.) van de patient gedurende dit SEH bezoek.

Detecting changes in the performance of a clinical machine learning tool over time

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Review Article

Artificial Intelligence: its Future and Impact on Acute Medicine

M Schinkel, K Paranjape, S Bhagirath & PWB Nanayakkara

The Value of Artificial Intelligence in Laboratory Medicine

Current Opinions and Barriers to Implementation

Ketan Paranjape, MS, MBA,^{1,*} Michiel Schinkel, MD,² Richard D. Hammer, MD,³ Bo Schouten, MSc,^{1,4} R. S. Nannan Panday, MD, PhD,² Paul W. G. Elbers, MD, PhD,⁵ Mark H. H. Kramer, MD,⁶ and Prabath Nanayakkara, MD, PhD²

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Clinical applications of artificial intelligence in sepsis: A narrative review
M. Schinkel^{a,1}, K. Paranjape^{a,1}, R.S. Nannan Panday^a, N. Skyttberg^b, P.W.B. Nanayakkara^{a,*}

Embracing cohort heterogeneity in clinical machine learning development: a step toward generalizable models

Michiel Schinkel^{1✉}, Frank C. Bennis², Anneroos W. Boerman³, W. Joost Wiersinga⁴ & Prabath W. B. Nanayakkara³



ABC Study Team

Multidisciplinary team:

- Drs. Sheena Bhagirath, PhD-candidate Acute Medicine
- Drs. Noucka van der Zaag, PhD-candidate Acute Medicine
- Drs. Amber den Hollander, PhD-candidate Acute Medicine
- Drs. Roos Boerman, PhD-candidate Acute Medicine and Clinical Chemistry, Resident Internal Medicine
- Dr. Michiel Schinkel, post-doc Acute Medicine and Infectious Disease, Data Scientist, Resident Internal Medicine
- Mei Lie, EPIC-team, implementation algorithm in EPIC
- Dr. Rogier Schade, Clinical Microbiologist
- Prof. dr. Joost Wiersinga, Internist-Infectiologist
- Prof. dr. Robert de Jonge, Clinical Chemist
- Prof. dr. Martijn Schut, Professor Translational AI
- Prof. dr. Prabath Nanayakkara, Internist Acute Medicine, Principal Investigator



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