

Harnessing the power of healthcare data: Advances in sepsis detection

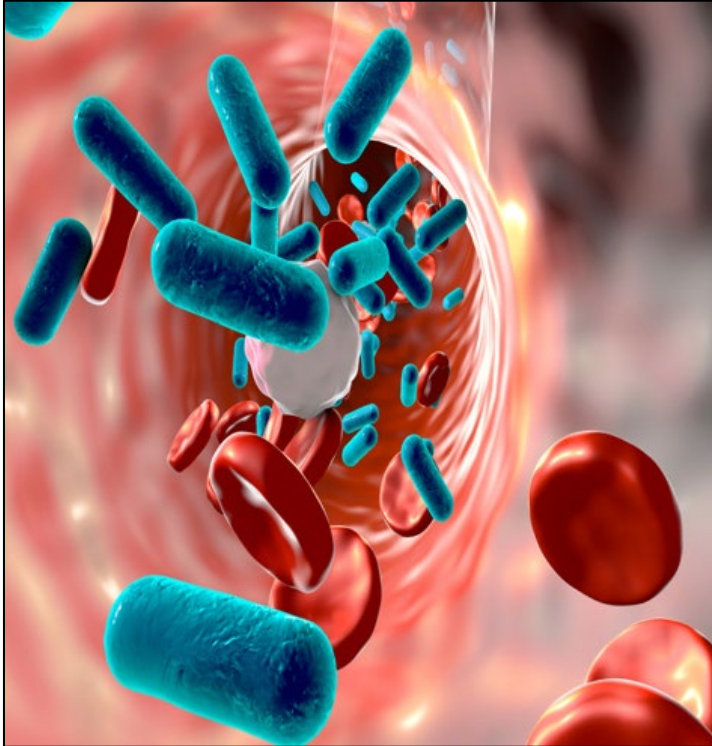
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National Institute for
Health Research

Early detection of serious infection outcomes: Digital alerts for sepsis



- **Sepsis** is a life-threatening illness caused by the body's response to an infection
- Rapid mortality
- Difficult to diagnose in a busy hospital environment

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Health

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Sepsis often missed as 50% of screening tools don't work, study finds

Research uncovers flaws in two of four tools used by health workers worldwide to diagnose condition



Denis Campbell Health policy editor
Wed 20 Sep 2023 00:19 BST

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25 October 2023



Martha's Rule to give NHS patients and families right to urgent second opinion

Martha's parents say they hope the formalising of the process for an urgent review can help save lives. At least 100 NHS trusts in England are expected to bring it in initially.

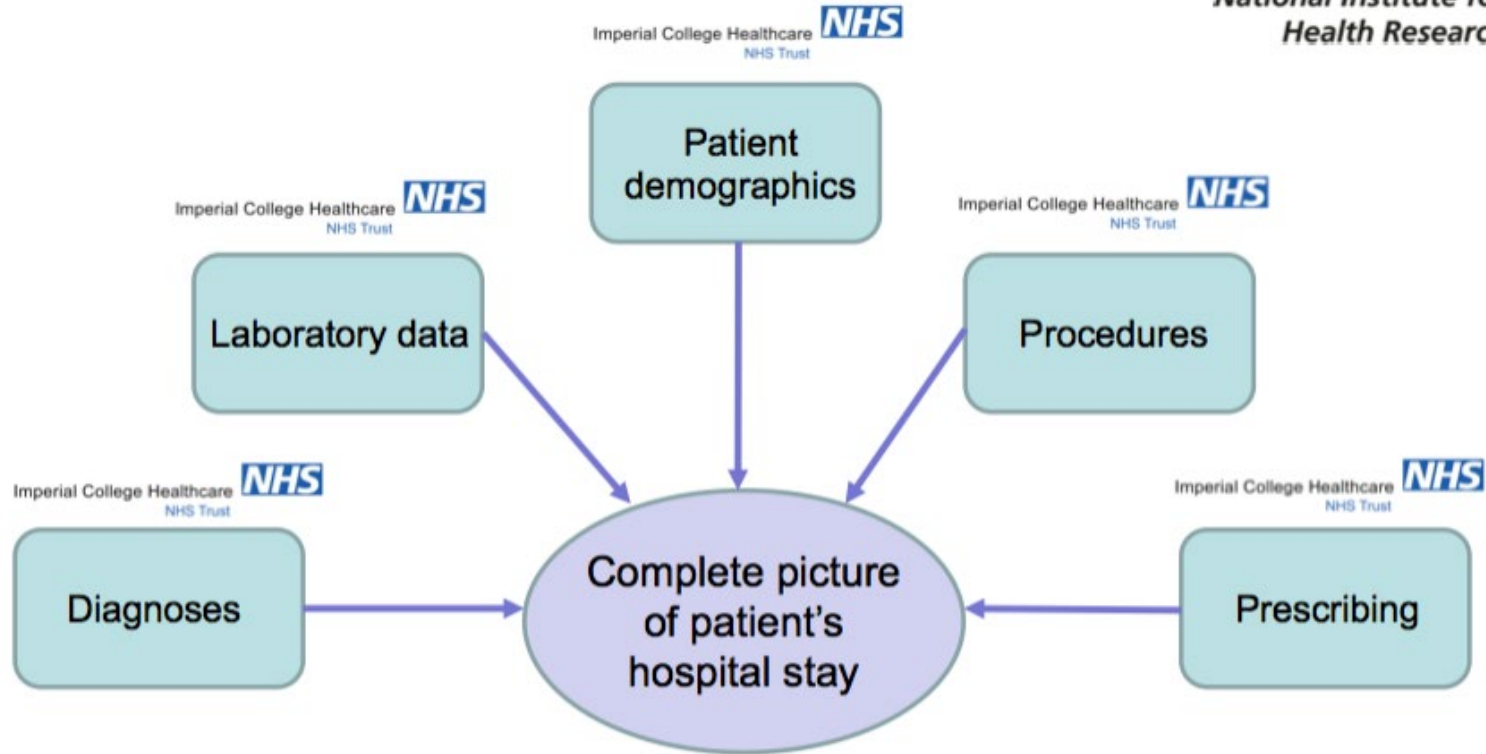
Boy died of sepsis after important GP note missed

Imperial College
London

Using real world healthcare data to evaluate digital tools in the early detection of sepsis

- Five hospitals across North West London
- Treating ~2 million patients per year
- Together with Imperial College London forms Academic Health Science Centre
- NIHR BRC funding





The impact of digital alerts for sepsis



Sepsis targets introduced in 2015/2016 to improve sepsis screening



Assess the performance of the digital sepsis alert – embedded in electronic patient records (EPR)

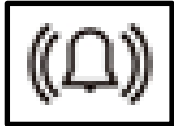


Evaluate the effect of digital sepsis alert on patient outcomes – mortality, length of stay, appropriate antibiotic therapy

Evidence of infection response	
Temperature	>38.3°C or <36°C
Heart rate	>95 beats/min
Respiratory rate	≥ 22 breaths/min
WBC	>12,000 or <4000 cells/mm ³
Glucose	<141 and >200 mg/dL

≥2 criteria

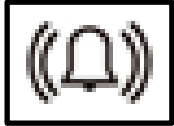
≥3 criteria
infection response



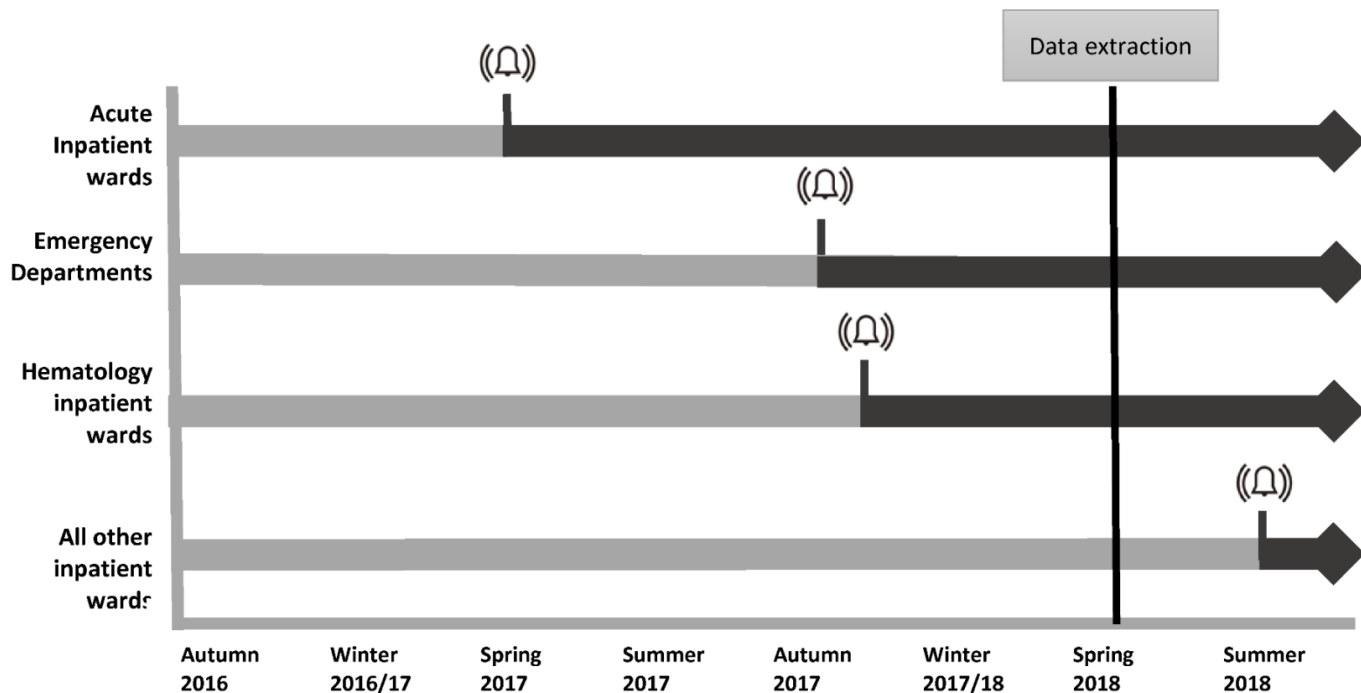
Suspicion of sepsis

Evidence of organ dysfunction	
SPB	<90 mmHg (30 hours)
Lactate	>2.0 mmol/L (12 hours)
Bilirubin:	2.0 mg/dL and <10.0 mg/dL (30 hours)
Creatinine:	Increase of ≥0.5 mg/dL from base-line (72 hours)

≥2 criteria
infection response
&
≥1 criteria
organ dysfunction



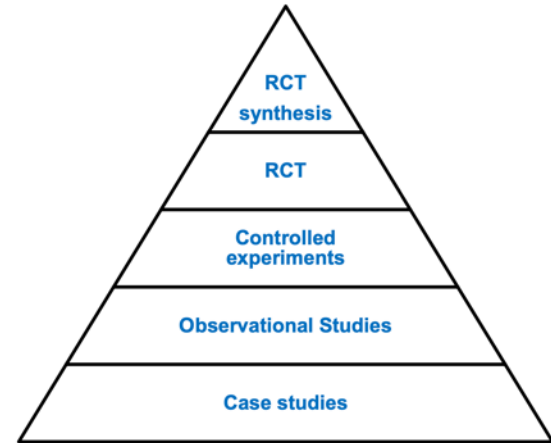
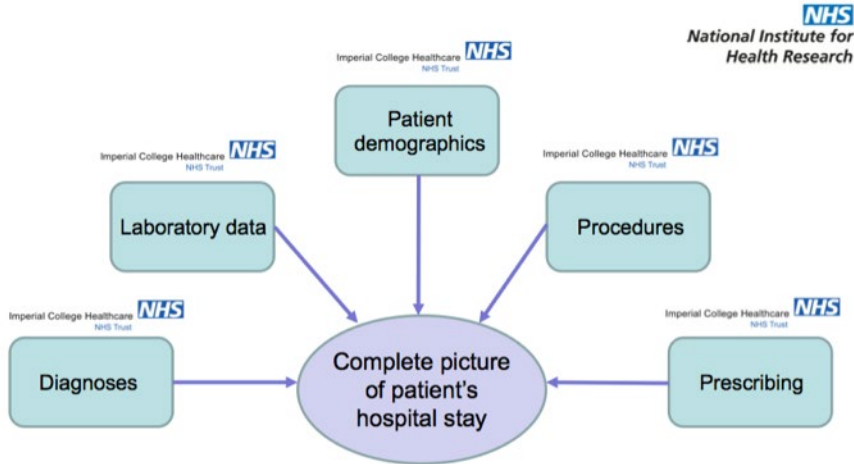
Suspicion of severe sepsis



- visible to clinicians - 'intervention' group
- running silently and not visible - control group



What is the impact of digital sepsis alert on patient outcomes – mortality, length of stay, appropriate antibiotic therapy



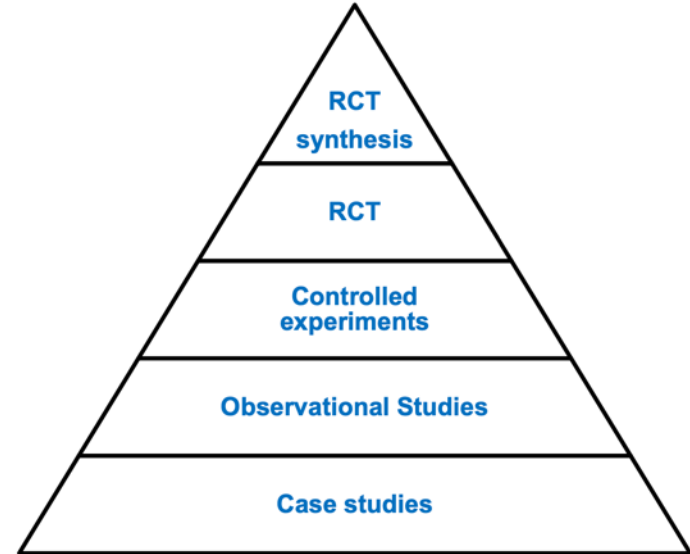
- Over 21,000 patients in an 18 month period
- Rich highly granular EPR data, research access for the first time
- Retrospective 'natural experiment'

What is the impact of digital sepsis alert on patient outcomes – mortality, length of stay, appropriate antibiotic therapy

Intervention group



Control group



What is the impact of digital sepsis alert on patient outcomes – mortality, length of stay, appropriate antibiotic therapy

Propensity Score Weighting

Intervention group



Intervention group



Control group



Control group



Results

In-hospital mortality in 30 days – all patients

Crude: Reduction from 6.4% to 5.1%

Doubly robust adjustment: **Lower risk of death - 24% lower**

Prolonged hospital stay (≥ 7 days) – patients admitted through the ED

Crude: Reduction from 41.1% to 40.2 %

Doubly robust adjustment: **Lower risk of extended stay - 4% lower**

IV antibiotics (within one hour of the alert) – patients admitted through the ED

Crude: Increase from 36.9% to 44.7%

Doubly robust adjustment: **Increased chance of receiving timely antibiotics - 35% higher**

Health

Sepsis digital alert 'led to faster treatment with antibiotics'

20 November 2019

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implemented across countries as essential approach to facilitate prompt treatment and improve patient outcomes in hospital setting. Digital screening tools have the advantage of being able to 'alert' staff to patients who meet eligibility for sepsis screening.

Are hospitals ready for digital innovation?

Whilst GP practices have been using EPRs for many years the same is true in hospital care. Our survey of NHS trusts in England suggests that EPR systems have been adopted by 89% of trusts, an increase from 77% in 2018. The introduction of EPR 'paperless' systems has meant a rapid rise in digital alerts in healthcare, including medication reviews in primary care.



MATT JEACOCK

Patients need urgent treatment before it starts damaging the body's own tissues and organs

News

Sepsis early warning technology could save thousands of lives, Imperial study finds

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Save



This follows calls that thousands of children are needlessly dying amid a lack of sepsis checks. Credit: MARTIN BARRAUD/GETTY IMAGES CONTRIBUTOR

Digital innovation in healthcare

Now is the time for digital innovation, argues Professor Ceire Costelloe at the Institute of Cancer Research, who argues that healthcare is ready to adopt digital transformation



There is currently over £1 billion a year devoted to digital transformation in the NHS. Digital innovation and digitisation of healthcare offer

then inform the co-design of digital interventions. Working with healthcare stakeholders, interventions can be implemented into practice. Using



Thousands could be saved from sepsis after major trial of monitoring system is 'success', scientists claim

- New technology automatically triggers an alert to doctors if sepsis is suspected
- Experts analysed data of more than 27,000 patients who triggered sepsis alert
- They compared the outcome of these patients with those with standard care

By ELEANOR HAYWARD HEALTH REPORTER FOR THE DAILY MAIL
PUBLISHED: 00:02, 20 November 2019 | UPDATED: 02:05, 20 November 2019

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TV REPORT 20 November 2019 at 12:03am

Sepsis alert system hailed for reducing deaths and hospital stays



Patients who were admitted to hospital had a 4% lower chance of staying for more than a week. Photo: Peter Byrne/PA



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Article Contents

Evaluating a digital sepsis alert in a London multisite hospital network: a natural experiment using electronic health record data

Kate Honeyford, Graham S Cooke, Anne Kinderlerer, Elizabeth Williamson, Mark Gilchrist, Alison Holmes, The Sepsis Big Room, Ben Glampson, Abdulrahim Mulla, Ceire Costelloe

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Digital Alerting to improve Sepsis detection and patient outcomes in NHS Trusts

Céire Costelloe (PI)

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Andrew Brent, Stephanie Little, Gail Roadknight, Sarah Tonkin-Crine,
Claire Burnett, Ron Daniels, Peter Ghazal, Shashank Patil, John Welch
PPI: Pippa Goodman

Funding: NIHR Health Service and Delivery research award



Determine the effectiveness of the introduction of digital alerts to improve outcomes of patients with sepsis in the UK

Aims

1. Map the digital alerts currently in use in multiple UK hospitals to identify patients at risk of having sepsis (WS1)
2. Evaluate the impact of digital alerts on outcomes for patients at risk of sepsis (WS2)
3. Explore implementation approaches and the impact of these on digital alert performance (WS3)
4. Make recommendations on the effectiveness of different digital alerts and the most effective method of implementation (WS4)

Developing and Evaluating Rapid Risk Stratification tools

- Little is known about the prevalence of digital alerts in English hospitals or the accuracy of the underlying algorithms

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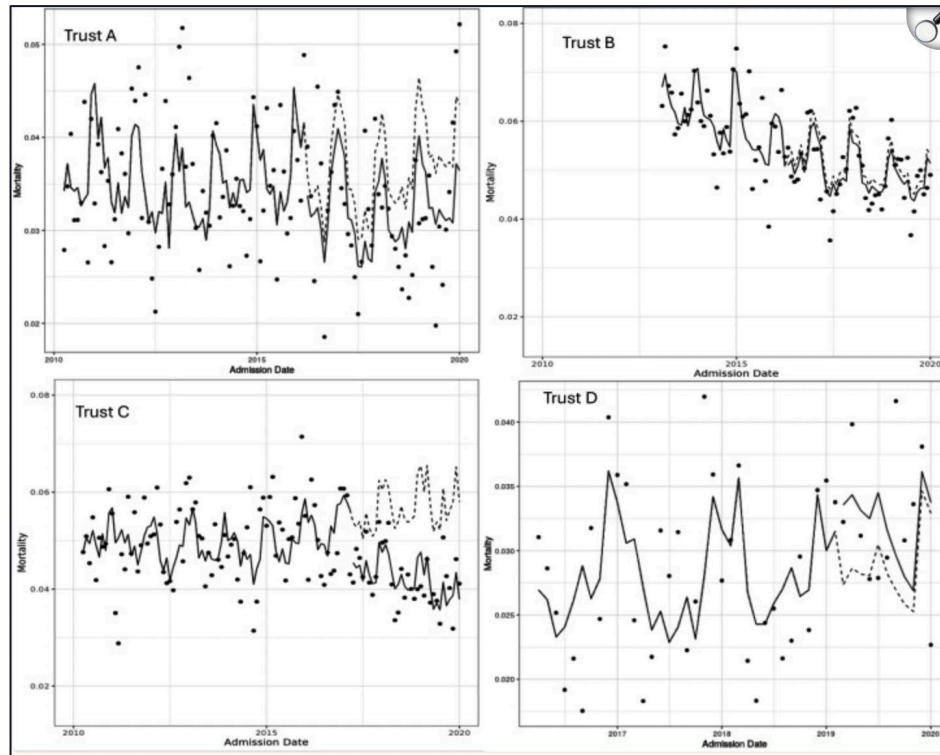
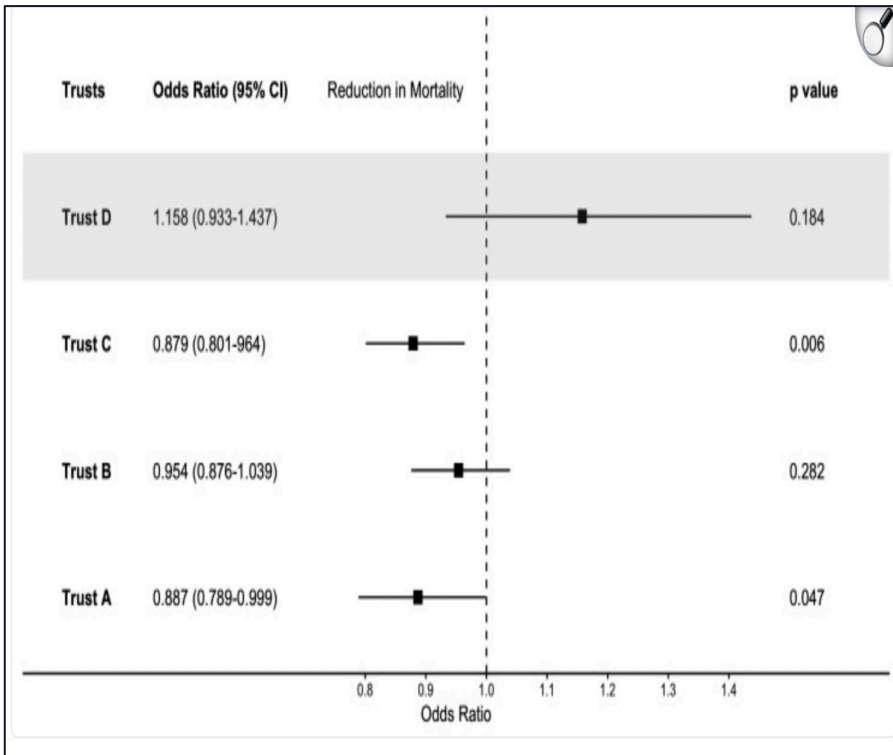
Original research

BMJ Health &
Care Informatics

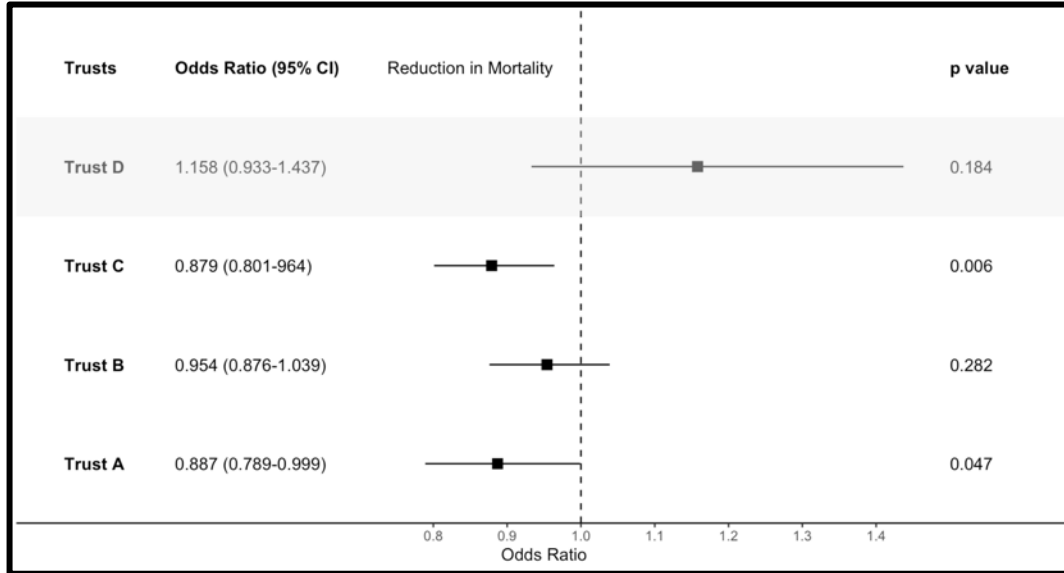
Prevalence of electronic screening for sepsis in National Health Service acute hospitals in England

Kate Honeyford ,¹ Amen-Patrick Nwosu ,² Runa Lazzarino,³
Anne Kinderlerer,⁴ John Welch,⁵ Andrew J Brent,^{6,7} Graham Cooke,^{4,8,9}
Peter Ghazal,¹⁰ Shashank Patil,¹¹ DiAIS Co-investigators, Ceire E Costelloe^{1,12}

Quantifying the impact of digital sepsis screening tools on patient outcomes a multi-site natural experiment



Impact of sepsis screening on mortality



- Sepsis tools are non sensitive or specific; capture information on ‘deterioration’
- Mixed results on the impact of existing screening tools on mortality
- Stratified analyses shows that tools have differential impact according to age

DiAIS: Digital Alerting to improve Sepsis detection and patient outcomes in NHS Trusts

- There is no agreed evidenced based algorithm – and hospitals are using a wide variety of approaches even when the fundamental screening tool is (National early warning score) NEWS2
- All hospitals are using some form of screening tool, but these are neither sensitive nor specific
- We have powerful digital systems (EPR: electronic patient record systems) that are using paper based algorithms (in some cases actual paper) and not yet exploiting laboratory data, let alone previous and current diagnoses, demographics, etc
- Predictive AI/machine learning is not being used
- Proprietary algorithms within EPR systems have no validation, no evaluation

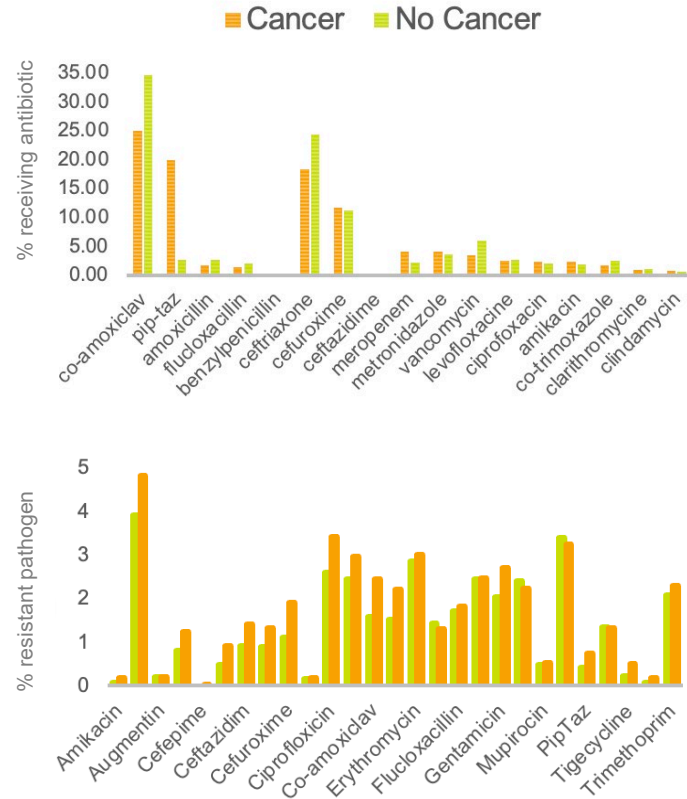
Digital alerts, which can access a patient's detailed EPR, have the potential to include detailed patient history and be tailored to patient history and conditions, and lead to better diagnosis and treatment

Sepsis in cancer patients

- Sepsis is a frequent complication in immunosuppressed cancer patients
- Patients with cancer are at > x10 higher risk for sepsis than the general population
 - In hospital for treatment and diagnosis including surgery and biopsies
 - Long term invasive treatments
 - Therapy to treat cancer
- These factors are not included in current sepsis alerts and current algorithms are not sensitive or specific for cancer patients

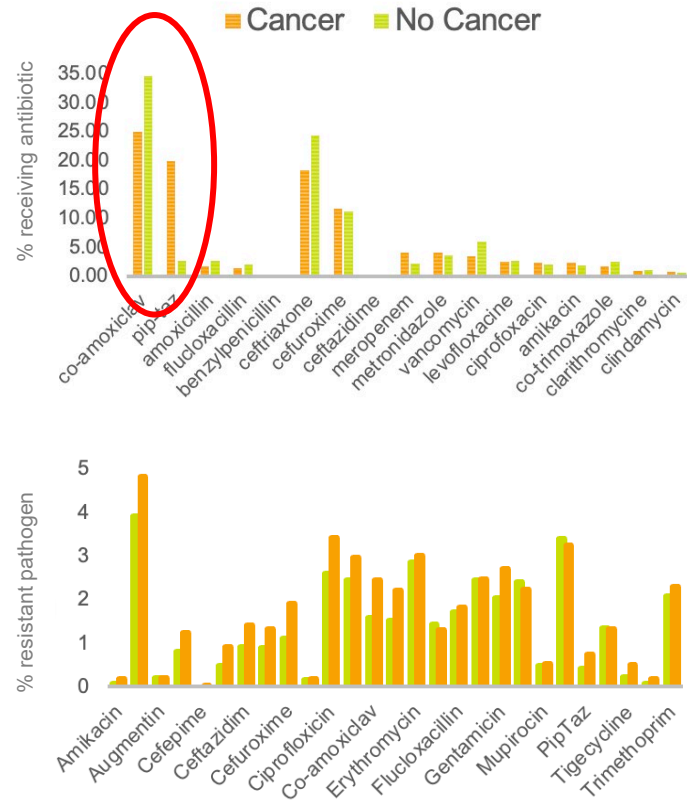
Digital alerting for sepsis in cancer patients

- In our example in a busy London hospital **26%** of digital alerts in a 12-month period were from patients with cancer (n=6559)
- All cancer patients are **more likely** to have a sepsis diagnosis than patients without cancer, the most common are those with a hematologic cancer
- Few have a blood culture confirmed sepsis diagnosis (gold standard)
- **73%** of cancer patients who alerted were administered an antibiotic – co-amoxiclav and pip-taz most commonly prescribed
- Higher prevalence of antibiotic resistant pathogen identified in blood cultures from cancer patients



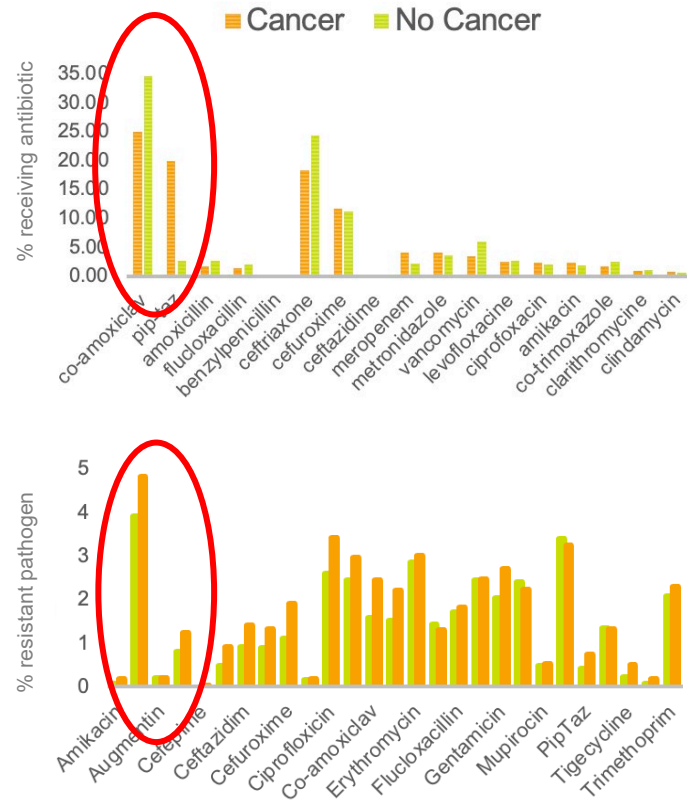
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Digital alerting for sepsis in cancer patients

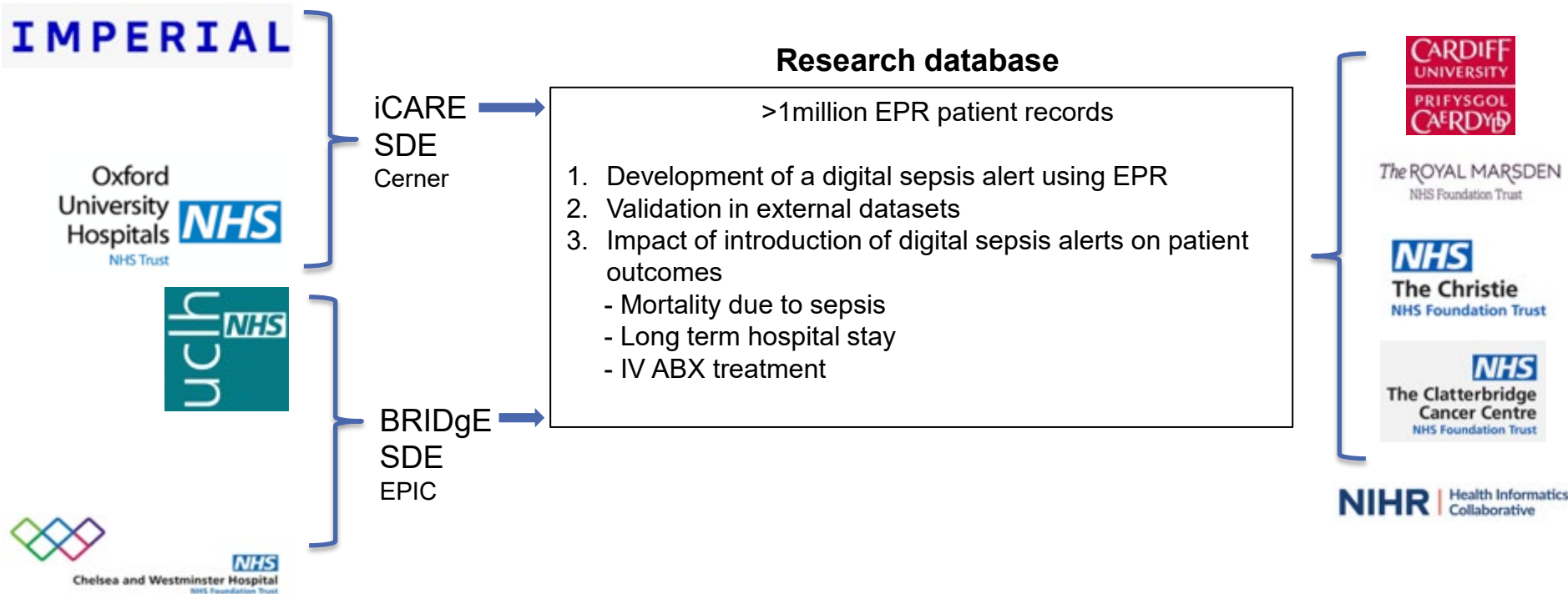
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Digital alerting for sepsis in cancer patients

- Judicious use of antibiotics is the cornerstone of AMR prevention strategies, overexposure to antibiotics is associated with increased likelihood of a subsequent AMR infection
- In our example in a busy London hospital 26% of digital alerts in a 12-month period were from patients with cancer, with 75% of those cancer patients who were alerted received a course of broad-spectrum antibiotic
- However, SJS algorithm is based on physiological criteria that are not suitable for cancer patient physiology
- These patients were also more likely to have a resistant pathogen identified in their blood compared with non-cancer patients
- If we are to use RSST/alerts they need to be sensitive and specific to the patient population we are trying to help

Data sharing for DiAIS study in partnership with NIHR



Developing and Evaluating Rapid Risk Stratification tools

- Patients with similar profiles have a lower mortality risk, consistent with our previous work. This study, conducted across multiple NHS Trusts, suggests that alerts could be tailored to specific patient groups based on age-related effects.
- The majority of English hospitals with EPRs use digital sepsis alerts, but these are simple alerts which lack sensitivity or specificity
- 'Off the shelf' algorithms can be proprietary 'black-box' lacking even basic validation, and clinical evaluation
- Detailed data from EPR could be used to improve digital sepsis alerts in hospitals and rapidly risk stratify patients for treatment



Novel Transparent Machine Learning Algorithm Predicting Sepsis from Routine ED Data

- Retrospective data from DiAIS study data from multiple NHS trusts
- A novel methodology to create a transparent machine learning algorithm using Shapley value approximations
- Three models in our study: (1) NNS1 was a shallow neural network representative of a “black box” algorithm. (2) ShAprox was a transparent approximation of NNS1 (3) ShAproxRef was a further refinement on ShAprox
- Model was validated in multiple NHS Trust data and ability to predict sepsis was examined

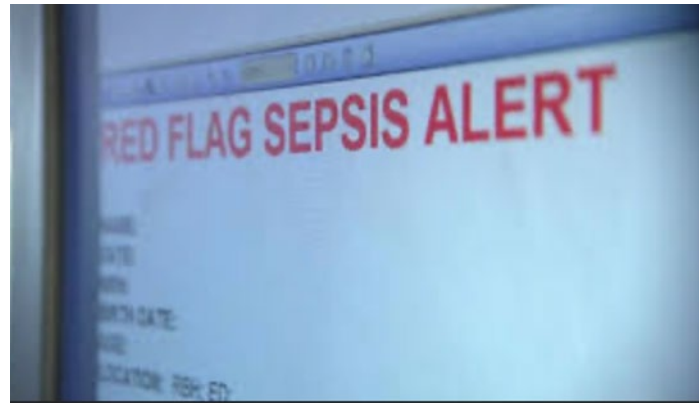
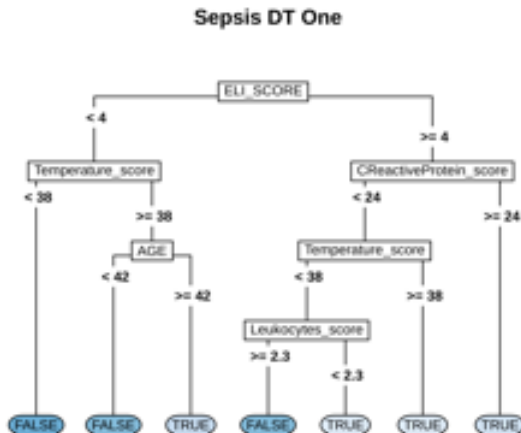
Results:

- 28,072 patient spells, 8.6% included a sepsis diagnosis.
- ShAproxRef achieved 0.74 AUC on internal testing and 0.82 AUC on external testing, both comparable to NNS1’s results.
- We offer a feasible approach to detect sepsis at the earliest time point, using a fully transparent algorithm improving clinical trust, and therefore aiding implementation.

Digital alerts for sepsis in cancer patients

Supervised learning approach (decision tree) to assign sepsis diagnosis based on rich EPR data

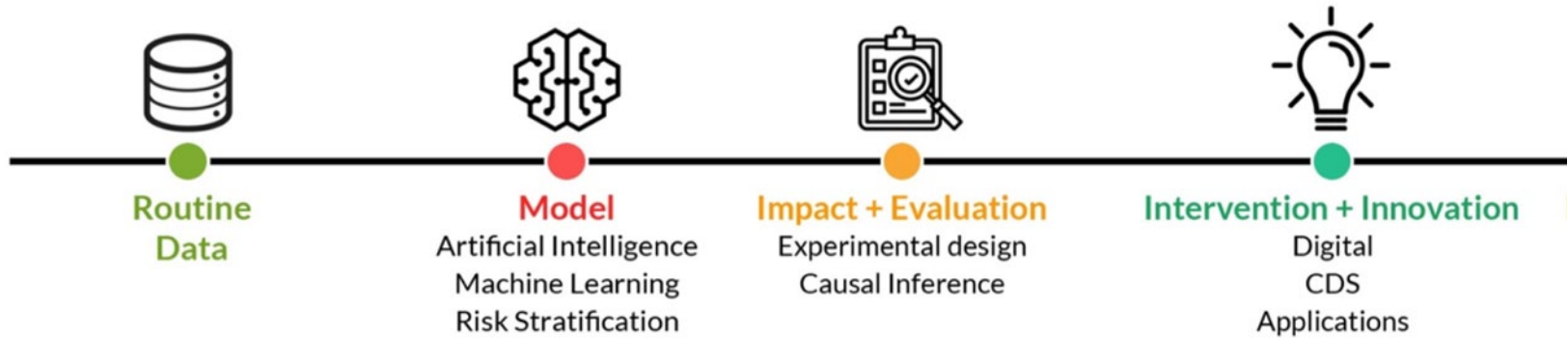
- Internal validation completed
- External validation with multiple NHS Trusts data
- Validation in Danish data set
- Cluster RCT of algorithm embedded within EPR systems in two NHS Trusts



Patient management of suspected neutropenic sepsis

- Patients advised to come to hospital if feeling unwell during chemotherapy
- 1 in 2 patients have normal neutrophil levels and did not need to attend hospital or receive intravenous antibiotics, accounting for over 50,000 preventable A&E attendances in the NHS annually
- NeutroCheck is a point of care (at home) test that identifies thresholds for continuous variables from blood (CRP and Neutrophils)
- Combined with demographic and symptom profile information high predictive power for an outcome of admission due to sepsis (where length of stay \geq 1 day)





Facilitators and barriers



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Challenges and recommendations for high quality research using electronic health records

K Honeyford^{1,2*†}, P Expert^{1,3†}, E.E Mendelsohn¹, B Post^{4,5},
A.A Faisal^{4,5,6,7}, B Glampson^{8,9}, E.K Mayer^{5,8,9} and C.E Costelloe^{1,2,10}

- Using data from real world health data effectively is dependent on synergy between researchers, clinicians and health informaticians, and only this will allow state of the art methods to be used to answer urgent and vital questions for patient care.
- There needs to be a paradigm shift in the way this research is conducted - appreciating that the research process is iterative rather than linear.
- Specific recommendations for organisations, based on our experience of developing and using real world healthcare data in Secure Data Environments (SDE).



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Group Health Informatics

PhD opportunities
Postdoctoral fellow positions

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Thank you

