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Machine learning based individualised intravenous-to-oral antibiotic switch decision support

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Why?

- **Antimicrobial resistance** (AMR) and healthcare associated infections (HCAIs) pose a significant **global threat**
- One key prevention strategy is to follow **antimicrobial stewardship** practices, in particular, to **switch from intravenous (IV) to oral** administration as early as possible and reduce the use of indwelling vascular devices
- Despite numerous infection prevention, safety and cost **benefits** as well as evidence, oral efficacy is often non-inferior to IV[1,2], the **uptake of early oral switching remains low[3]**

Aim

Develop a **real time**, **interpretable machine learning** based **clinical decision support system** for predicting when a patient can **safely switch from IV to oral** treatment based on **routinely collected clinical parameters**.

How?

- Patients receiving intravenous antibiotics (<8 days) followed by oral treatment were selected from **Imperial College Healthcare NHS Trust** historical electronic health record data
- Extracted features from the UK Health Security Agency antimicrobial **IV-to-oral switch guidelines[4]** and processed them with the catch22 methodology[5]
- Included patients' **demographics and co-morbidities** as features; **similar patients can be retrieved** via nearest neighbour lookup in the embedding space
- Trained **machine learning models** to predict patients route of administration on each day
- Developed a **web app** to **quantify differences in prescribing behaviours** with the decision support system versus standard of care and evaluate **user acceptability**

Results

NHS Imperial College Healthcare NHS Trust

5,610 and 547 unique stays were extracted from the research and prospective datasets respectively.

Metric	Hold-out dataset	Pneumonia patients	Sepsis patients	UTI patients	Bad bio-availability	Prospective dataset
AUROC	0.79 (SD 0.01)	0.79 (SD 0.02)	0.81 (SD 0.01)	0.80 (SD 0.03)	0.76 (SD 0.09)	0.77
ACCURACY	0.71 (SD 0.01)	0.72 (SD 0.02)	0.75 (SD 0.01)	0.72 (SD 0.02)	0.68 (SD 0.09)	0.70
TPR	0.66 (SD 0.03)	0.68 (SD 0.06)	0.71 (SD 0.03)	0.68 (SD 0.04)	0.61 (SD 0.21)	0.61
FPR	0.21 (SD 0.03)	0.22 (SD 0.03)	0.21 (sD 0.03)	0.21 (SD 0.05)	0.21 (SD 0.08)	0.20

Table 1: Average binary classification results for 10 models trained, validated and tested on the research, specific subsets and prospective datasets.

AUROC, Area Under the Receiver Operating Characteristic curve; TPR, True Positive Rate; FPR, False Positive Rate

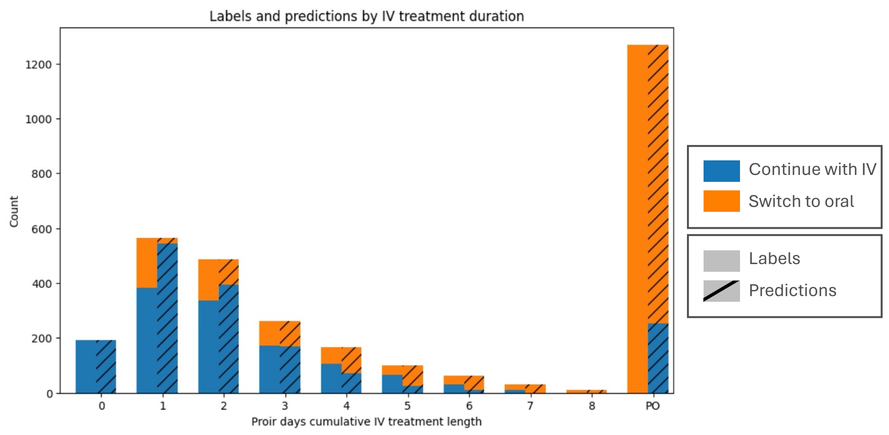


Figure 1: Labels and predictions by intravenous treatment duration on an unseen test set by a hold-out model. Based on clinical parameters the model predicts that from day 6 onwards most patients can switch to oral therapy.

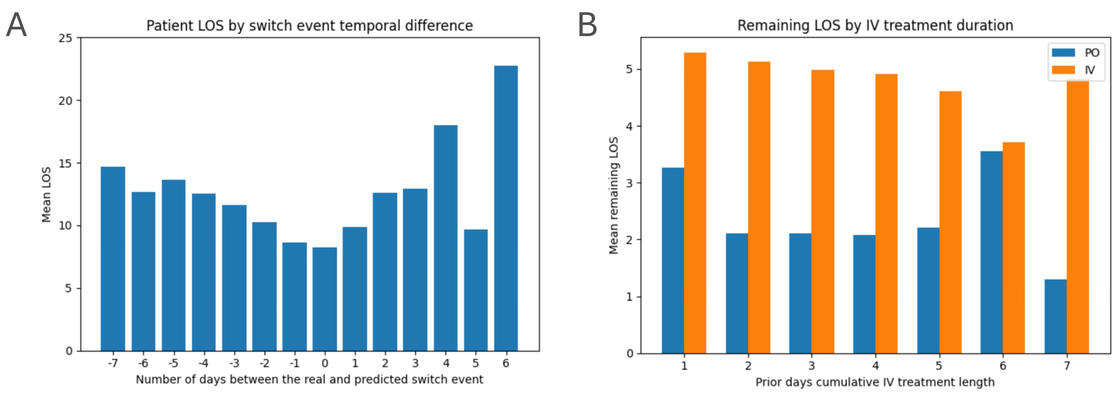
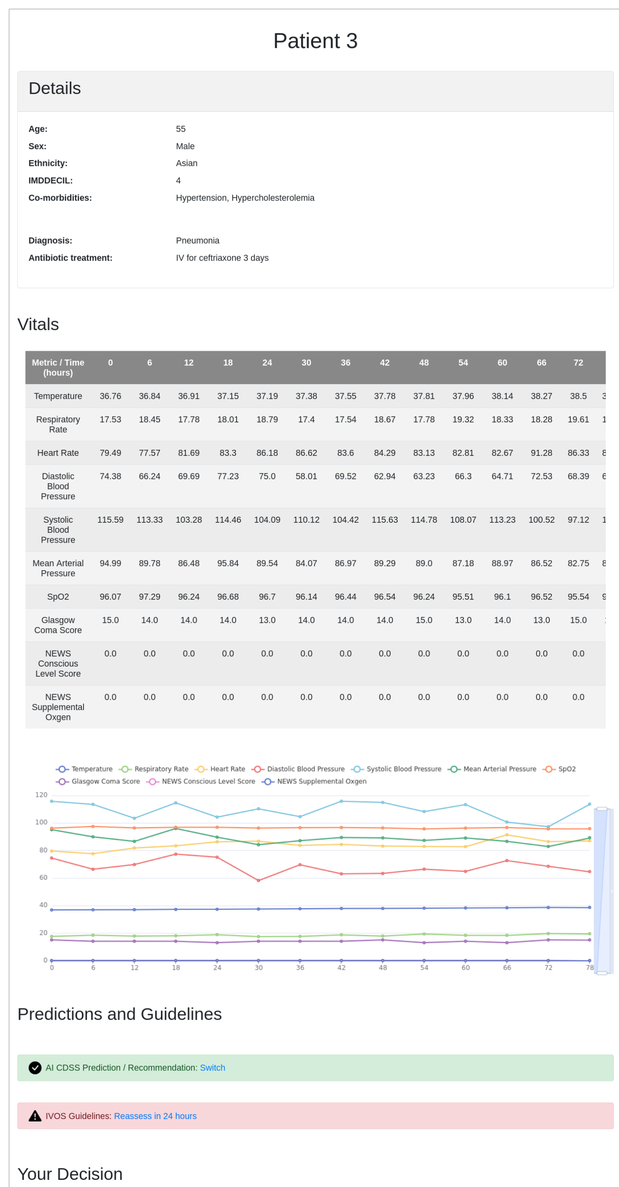


Figure 2: [A] Mean patient LOS outcomes by days between the real and predicted switch event. A negative number on the x axis indicates the predicted switch event was before the real switch event. The opposite is true for positive numbers, while 0 means they occurred on the same day. [B] Remaining LOS broken down by IV treatment duration for those with oral and IV administration. Those patients on oral therapies on average have a shorter remaining LOS than those on IV.

LOS, Length of stay; IV, Intravenous; PO, Oral



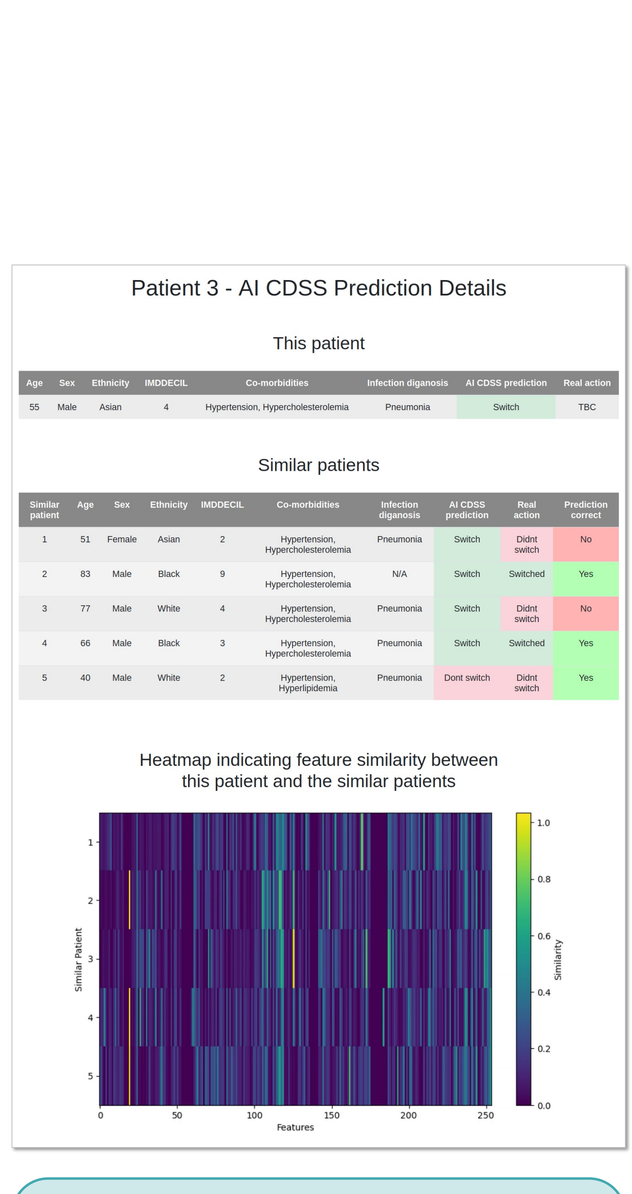


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Figure 3: Example of a particular patient from the web app demo. Patient details are clearly presented alongside recommendations based on the AI CDSS predictions and the latest guidelines[4]. If interested the user can obtain more information on the reasons behind these recommendations, including comparing historically similar patients and their features.

Discussion

- Identified **clinically relevant features** and created novel machine learning models to determine **when switching may be appropriate for a particular patient**
- **Interpretability** through retrieving similar patients and comparing features creates a **clinically useful decision support** system that can be understood
- Developed a **user interface** for **end user assessment** to understand **acceptability and how such a system could influence antimicrobial decision making**
- Future work includes **real-world prospective evaluation** to understand this technology's **safety and clinical benefit** towards promoting appropriate early switching, as well as how to **implement the tool into routine clinical practice**

Acknowledgements

William Bolton was supported by the UKRI CDT in AI for Healthcare http://ai4health.io (Grant No. P/S023283/1) and by the National Institute for Health, Health Protection Research Unit in Healthcare Associated Infections and Antimicrobial Resistance at Imperial College London in partnership with the UK Health Security Agency (previously PHE), in collaboration with, Imperial Healthcare Partners, University of Cambridge and University of Warwick. He is also affiliated to the Department of Health and Social Care, Centre for Antimicrobial Optimisation.

References

[1] Noah Wald-Dickler et al. "Oral Is the New IV. Challenging Decades of Blood and Bone Infection Dogma: A Systematic Review". English. In: The American Journal of Medicine 135.3 (Mar. 2022). Publisher: Elsevier, 369–379.e1. issn: 0002-9343, 1555-7162. doi: 10.1016/j.amjmed. 2021.10.007. [2] Jan Jelrik Oosterheert et al. "Effectiveness of early switch from intravenous to oral antibiotics in severe community acquired pneumonia: multicentre randomised trial". en. In: BMJ 333.7580 (Dec. 2006). Publisher: British Medical Journal Publishing Group Section: Research, p. 1193. issn: 0959-8138, 1468-5833. doi: 10.1136/bmj.38993.560984.BE. [3] Duane R Hospenthal et al. "Practice Patterns of Infectious Diseases Physicians in Transitioning From Intravenous to Oral Therapy in Patients With Bacteremia". In: Open Forum Infectious Diseases 7.12 (Dec. 2020), ofz386. issn: 2328-8957. doi: 10.1093/ofid/ofz386. [4] UK Health Security Agency. National antimicrobial intravenous-to-oral switch (IVOS) criteria for early switch. en. Nov. 2022. [5] Carl H. Lubba et al. "catch22: CAnonical Time-series CHaracteristics". en. In: Data Mining and Knowledge Discovery 33.6 (Nov. 2019).