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AHealth
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centre for antimicrobial optimisation

Machine learning based white blood count estimation for individualised antimicrobial cessation

William Bolton

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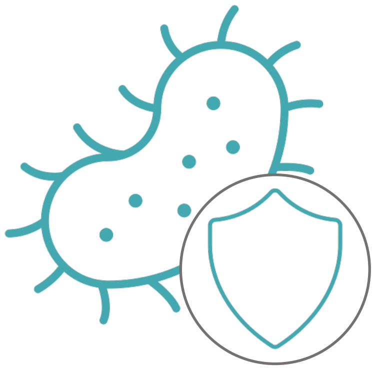
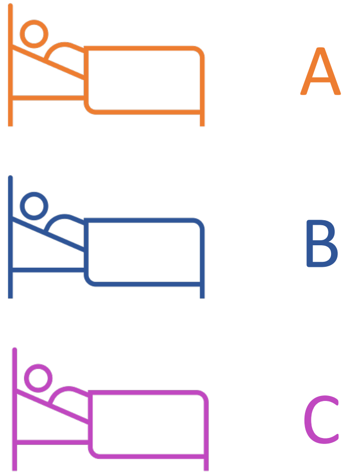
Machine learning can support optimised antibiotic decision making.



Antimicrobial resistance (AMR) is a global threat and one key strategy to tackle this is to optimise antimicrobial use



Clinical decision support systems (CDSSs) utilising machine learning (ML) have been developed to assist with managing infections

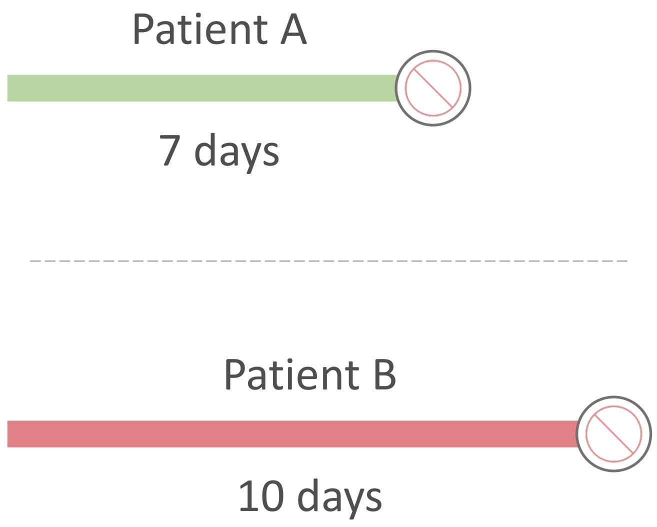
STAGES OF ANTIBIOTIC DECISION MAKING

1. Infection or not
2. Empiric treatment
3. Narrow therapy — IV to oral switch
4. Duration — Cessation, Side effects

Antibiotic cessation decision making is complex and under-researched.

One key challenge when treating a patient who has a bacterial infection is determining when it is appropriate to stop antibiotic treatment

Numerous studies have shown that on a population level, shorter treatment durations are often non-inferior to longer ones



There is a poor understanding of the factors that facilitate or inhibit an individual from receiving a short duration of therapy

Aim

Utilise a machine learning and synthetic control-based approach to estimate patients total white blood cell count for any given day, if they were to stop vs. continue antibiotic treatment

Routinely collected electronic health record data and an autoencoder were used for white blood cell count prediction.

DATASET

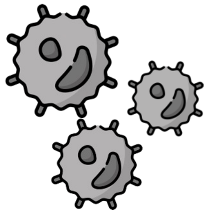
MIMIC-IV
>40,000 ICU patients

ICU intravenous antibiotic treatment (days<8)

OUR DATASET
7,867 unique ICU stays

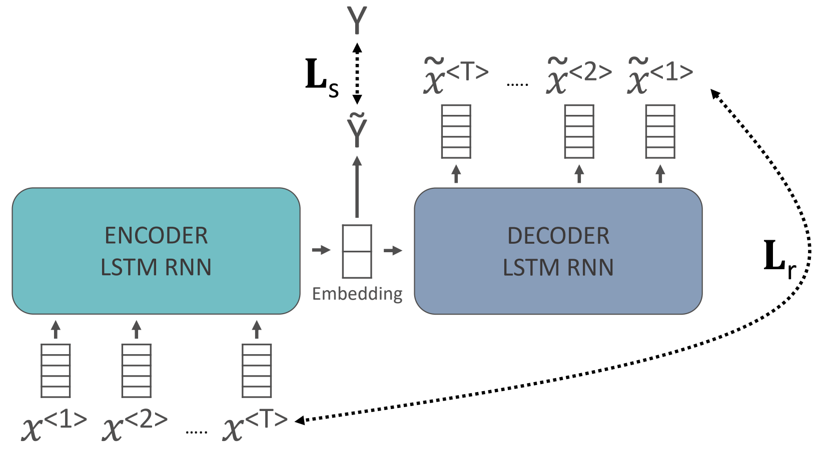
77 features

Total white blood cell count (WBC)



MODEL

Autoencoder



The encoder is trained using both a supervised loss (L_s) and reconstruction loss (L_r)

The autoencoder achieves reasonable WBC prediction performance and can be used for synthetic scenario estimation.

AUTOENCODER PREDICTIONS

77 features

Evaluation metric	Value
RMSE	3.28
MAE	2.68
MAPE	0.31

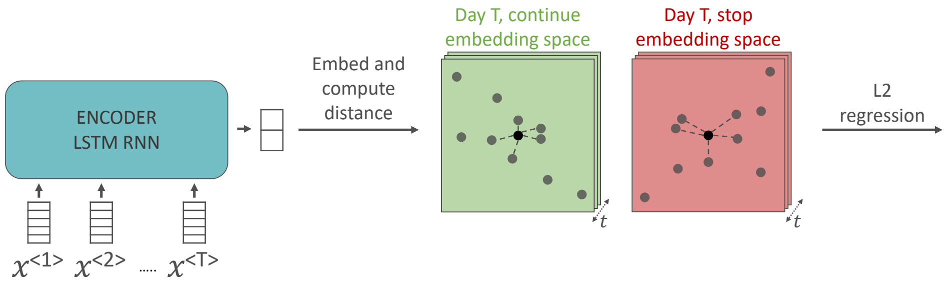
Feature selection

22 features

Evaluation metric	Value
RMSE	3.33
MAE	2.66
MAPE	0.36

SYNTHETIC ESTIMATION

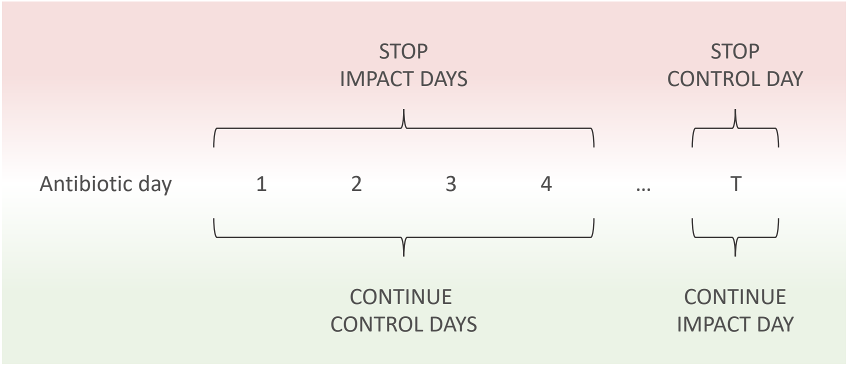
Methodology



$$\tilde{Y}_i^{S,t} = \sum_{j=1}^{k} \omega_{i,j}^{S,t} Y_{i,j}^{S,t}$$

$$\tilde{Y}_i^{C,t} = \sum_{j=1}^{k} \omega_{i,j}^{C,t} Y_{i,j}^{C,t}$$

Evaluation



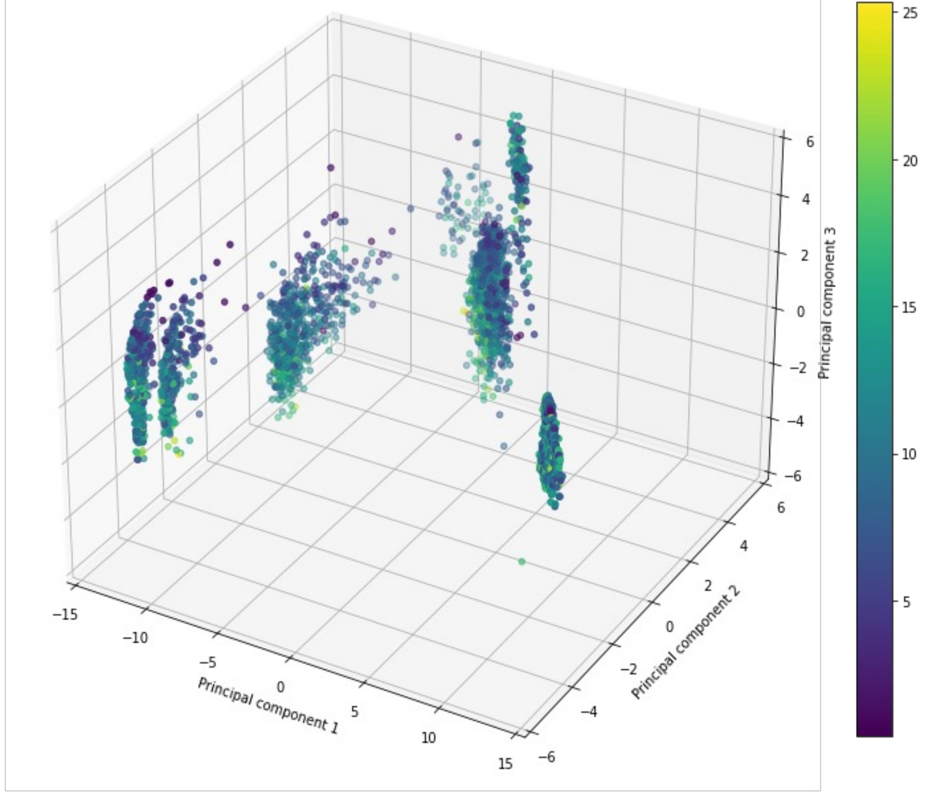
Our model can estimate patients white blood cell count under alternative antibiotic treatment.

SYNTHETIC WBC ESTIMATION RESULTS

Evaluation table

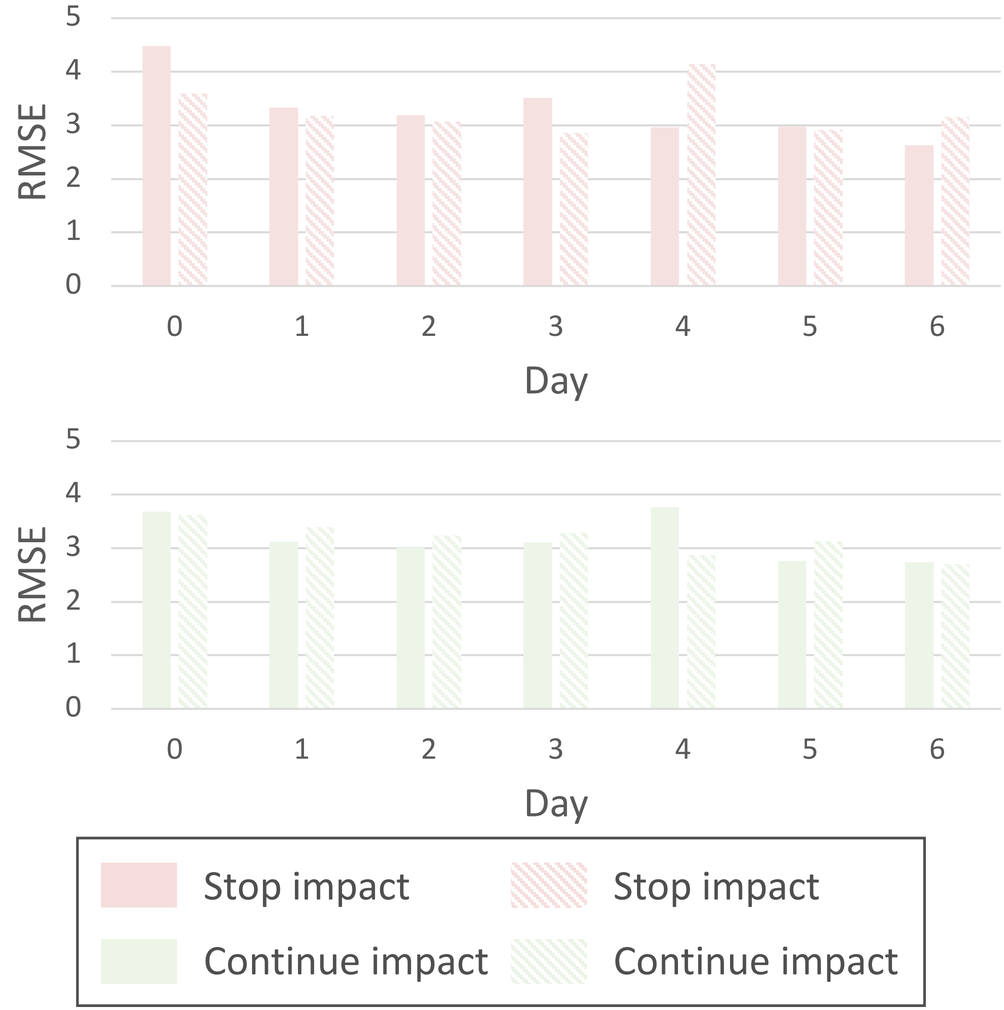
Scenario	Day(s)	WBC			
		Mean delta (days, p-value)	MAPE	MAE	RMSE
Stop	Impact	0.71*, <0.01	0.34	2.99	3.89
	Control	0.00, 0.06	0.32	2.50	3.24
Continue	Impact	-0.31*, <0.01	0.33	2.53	3.18
	Control	0.02*, 0.01	0.32	2.70	3.44

Embedding visualisation



Machine learning and synthetic outcome estimation for individualised antimicrobial cessation.

CONSISTENT ESTIMATION RESULTS



SYNTHETIC OUTCOME ESTIMATION

43 features

Mortality

Length of stay

frontiers in Digital Health

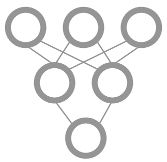
SCENARIO	DAY(S)	LOS				Mortality		
		Mean delta (days, p-value)	MAPE	MAE	RMSE	Mean delta	MAE	AUROC
STOP	IMPACT	2.71*, <0.01	0.36	3.30	4.80	0.06	0.25	0.66
	CONTROL	0.24, 0.60	0.26	1.32	1.93	0.05	0.15	0.72
CONTINUE	IMPACT	-2.09*, <0.01	0.77	2.85	3.16	0.05	0.18	0.67
	CONTROL	0.42*, 0.01	0.48	2.72	3.76	0.07	0.24	0.64

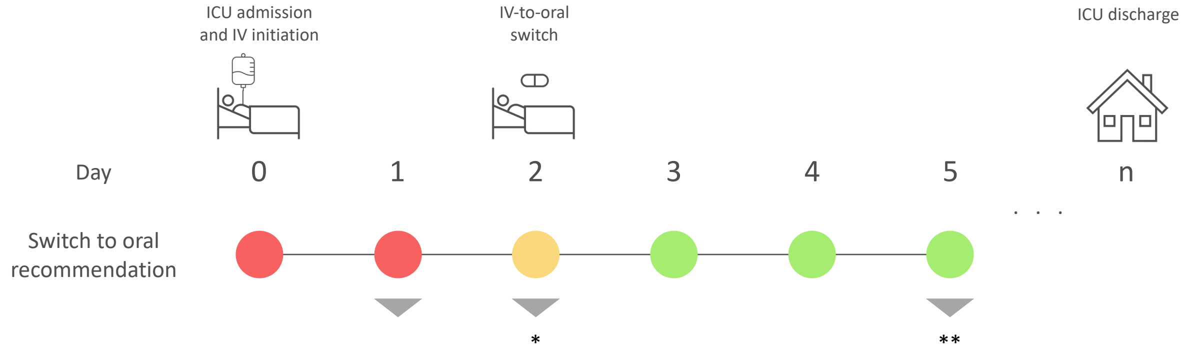
Other work includes machine learning to support IV to oral switching and understanding the impact of co-morbidities.

P3491

make the switch
FROM IV TO ORAL ANTIBIOTICS

UKHSA IVOS criteria





Day 1

Highlights

- Both thresholds predict switching is **not appropriate** at this time
- Predictions were correct for **100%** of similar examples
- O2 saturation pulseoximetry (feature 4) was of particular interest for these predictions

		Importance	Feature 1	Feature 2	Feature 3	Feature 4	Feature 5	Switch to oral label	Switch to oral prediction: 1st threshold	Switch to oral prediction: 2nd threshold
Patient		-	0.32	0.51	0.37	0.50	0.41	0	0	0
Example	1	0.28	0.38	0.54	0.29	0.48	0.46	0	0	0
	2	0.25	0.31	0.55	0.28	0.51	0.50	0	0	0
	3	0.21	0.29	0.52	0.45	0.52	0.46	0	0	0
	4	0.13	0.32	0.55	0.36	0.51	0.00	0	0	0

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TOP RATED POSTER
ECCMID 2023

AMR-UTI: Antimicrobial Resistance in Urinary Tract Infections

Days preceding	Arrhythmia	HTN	Hypothyroid	Pulmonary	FluidsLytes	Lymphoma	CHF	Obesity	PVD	Rheumatic	BloodLoss	DM	Renal	Depression	NeuroOther
7	<0.01	<0.01	0.11	<0.01	<0.01	0.63	<0.01	0.02	<0.01	0.21	0.01	<0.01	<0.01	<0.01	0.01
14	<0.01	<0.01	0.04	<0.01	<0.01	0.54	<0.01	0.02	<0.01	0.05	0.01	<0.01	<0.01	<0.01	<0.01
30	<0.01	<0.01	0.01	<0.01	<0.01	0.57	<0.01	0.03	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01
90	<0.01	<0.01	<0.01	<0.01	<0.01	0.83	<0.01	0.61	<0.01	0.1	0.05	<0.01	<0.01	<0.01	<0.01
180	<0.01	<0.01	<0.01	<0.01	<0.01	0.78	<0.01	0.88	<0.01	0.19	<0.01	<0.01	<0.01	<0.01	<0.01

Days preceding	Paralysis	Valvular	Coagulopathy	Anemia	Alcohol	HTNcx	Tumor	WeightLoss	Liver	Psychoses	DMcx	Drugs	Mets	PUD	PHTN	HIV
7	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.12	<0.01	0.2	<0.01	0.03	<0.01	0.93	<0.01	0.05
14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.23	<0.01	0.04	<0.01	0.93	<0.01	0.05
30	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.56	<0.01	0.03	<0.01	0.78	<0.01	<0.01
90	<0.01	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.01	<0.01	0.87	<0.01	<0.01
180	<0.01	<0.01	0.13	0.03	0.02	<0.01	<0.01	0.02	<0.01	0.4	<0.01	0.04	<0.01	0.7	<0.01	<0.01

Figure 1: Co-morbidities and empiric UTI treatment chi-square test of independence p-value results for differing diagnoses time windows preceding treatment. Green indicates statistical significance while red signifies no statistical significance.

UTI, Urinary Tract Infection; HTN, Hypertension; CHF, Congestive Heart Failure; PVD, Peripheral Vascular Disease; DM, Diabetes Mellitus; PUD, Peptic Ulcer Disease; PHTN, Pulmonary Hypertension; HIV, Human Immunodeficiency Virus

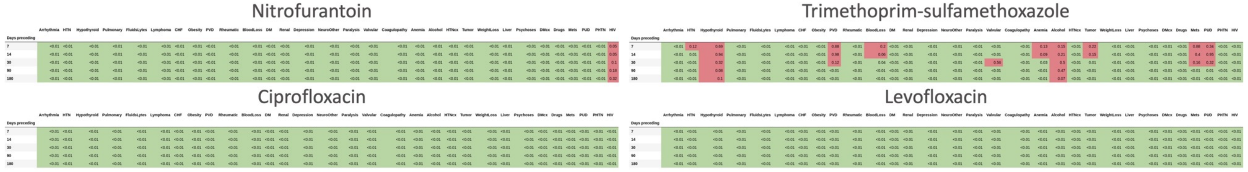
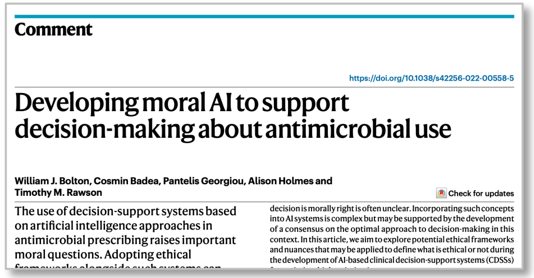


Figure 2: Co-morbidities and antimicrobial resistance chi-square test of independence p-value results for differing diagnoses time windows preceding resistance testing. Results are shown for four of the most common antibiotics used to treat UTI infections. Green indicates statistical significance while red signifies no statistical significance.

UTI, Urinary Tract Infection; HTN, Hypertension; CHF, Congestive Heart Failure; PVD, Peripheral Vascular Disease; DM, Diabetes Mellitus; PUD, Peptic Ulcer Disease; PHTN, Pulmonary Hypertension; HIV, Human Immunodeficiency Virus

Patient, public and stakeholder views as well as ethical theories have been considered to ensure solutions are fair.

ETHICAL VIEWPOINT


Comment

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Developing moral AI to support decision-making about antimicrobial use

William J. Bolton, Cosmin Badea, Pantelis Georgiou, Alison Holmes and Timothy M. Rawson

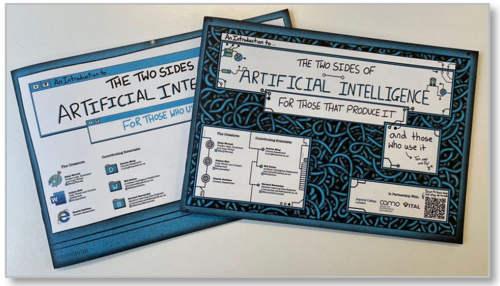
Check for updates

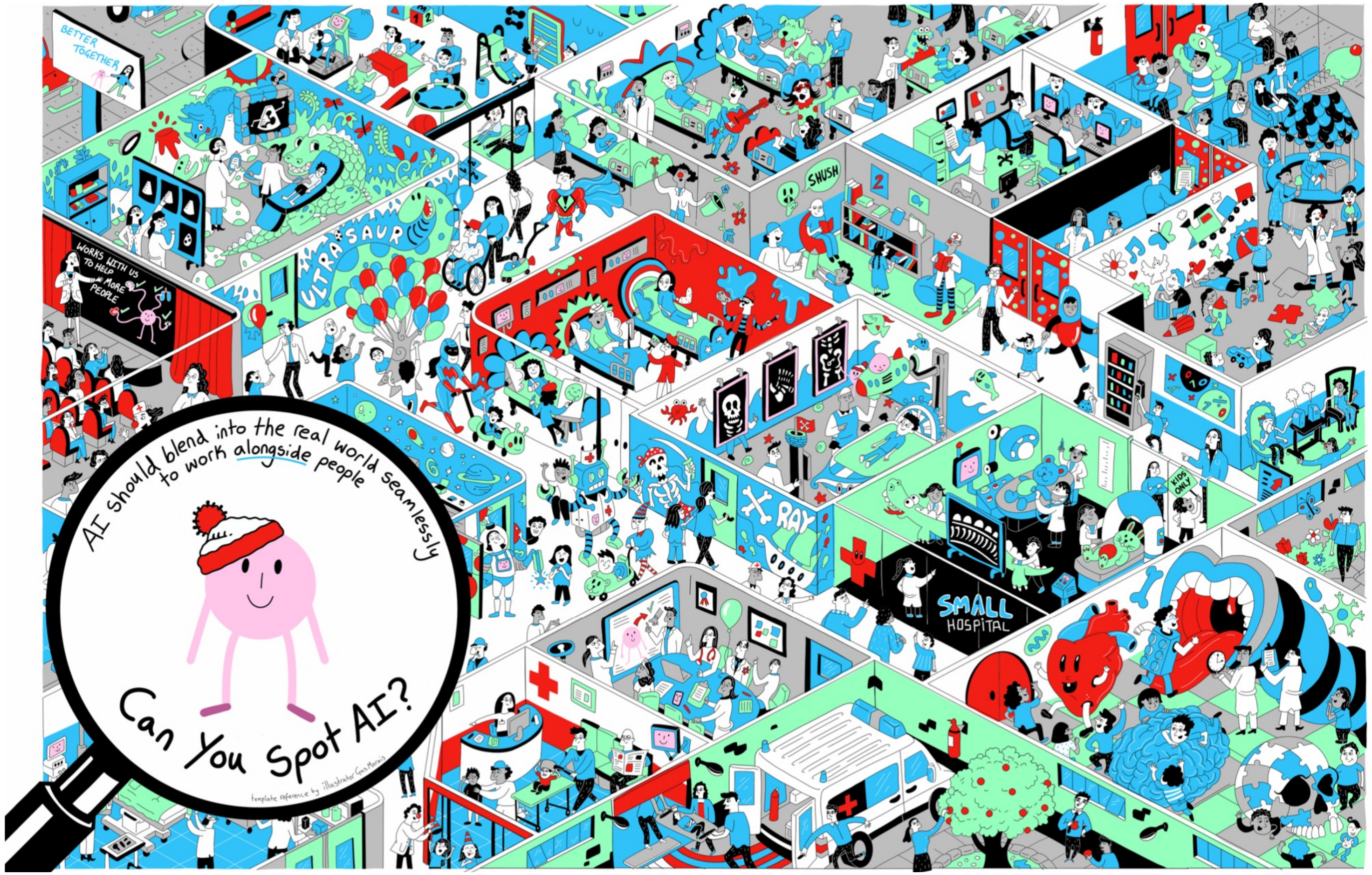
The use of decision-support systems based on artificial intelligence approaches in antimicrobial prescribing raises important moral questions. Adopting ethical …

decision is morally right is often unclear. Incorporating such concepts into AI systems is complex but may be supported by the development of a consensus on the optimal approach to decision-making in this context. In this article, we aim to explore potential ethical frameworks and nuances that may be applied to define what is ethical or not during the development of AI-based clinical decision-support systems (CDSSs)

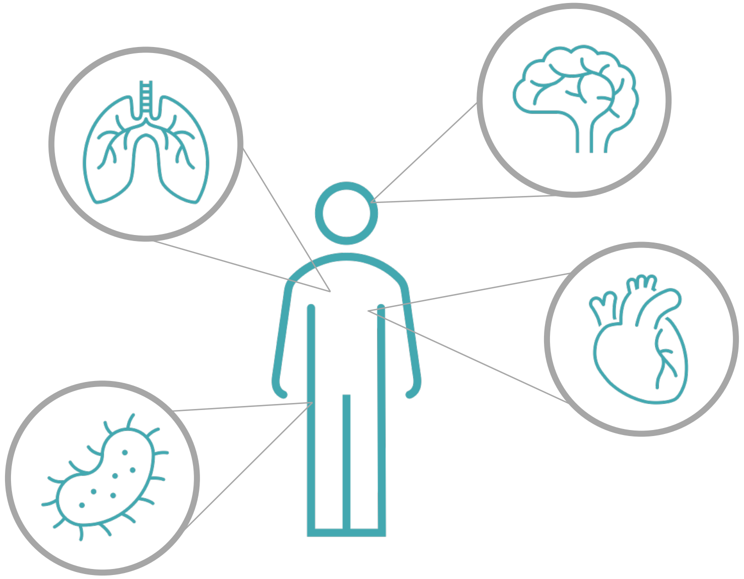
nature machine intelligence

PRIMARY RESEARCH

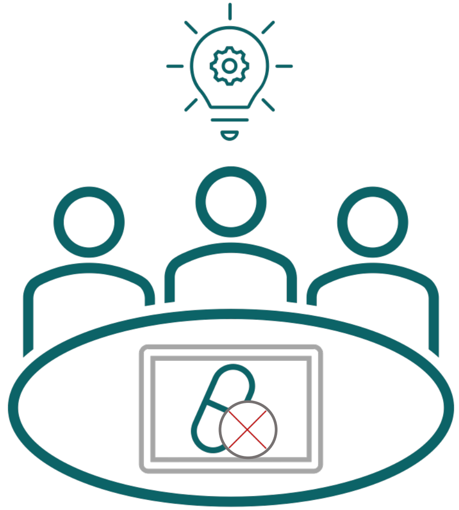




Future research includes modeling patients' co-morbidities and addressing AI biases.



Model infection patients' co-morbidities through graphical methods



Investigate other aspects of antibiotic optimization and explore testing algorithms in real-world clinical settings

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AI Health CAMO centre for antimicrobial optimisation

Thank you!

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Developing Moral AI to Support Antimicrobial Decision Making.

Health CAMO centre for antimicrobial optimisation

Regarding antimicrobial decision making, we believe a **utilitarian approach** is most suitable for developing AI-based CDSSs, and that technology should focus on the **likelihood of drug effectiveness and that of resistance** in order to have the biggest impact on supporting moral antimicrobial prescribing (Table. 1). Furthermore, for antimicrobials, **spatial and temporal considerations are critical** to optimise treatment outcomes and minimise the development of side effects or AMR. Decision making in antimicrobial prescribing is frequent, pressing, and both morally and technically complex. But by applying ethical theories to specific scenarios and incorporating moral paradigms, we can **ensure that AI-based CDSSs tackle global problems, such as the emerging AMR crisis, in a moral way.**

Variables	Description	Exemplar of starting antimicrobial treatment	Corresponding ad-hoc utility value
Intensity	How strong is the pleasure?	Treating a relevant infection with antimicrobials has the potential to save that person's life	Highly positive utility
Duration	How long will the pleasure last?	Any extension of life is immeasurable while it is reasonable AMR will continue in the near-term future	Positive utility
Certainty or uncertainty	How likely or unlikely is it that the pleasure will occur?	Limited information often means treatment may or may not be helpful and there is always an inherent risk of developing AMR	Neutral utility, without more information
Propinquity	How soon will the pleasure occur?	Treatment can be effective immediately however the same is true for the evolution of AMR	Neutral utility, without more information
Fecundity	The likelihood of further sensations of the same kind	-	Unable to assign
Purity	The likelihood of not being followed by opposite sensations	-	Unable to assign
Extent	How many people will be affected?	Prescribing antimicrobials effects the patient and those close to them, while the development of AMR is a certainty and may affect everyone, causing significant suffering and mortality	Immense negative utility

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Co-morbid obesity leads to significantly worse infection outcomes.

MEAN	BODY MASS INDEX (BMI)	LENGTH OF ICU STAY	ANTIBIOTIC TREATMENT LENGTH
HEALTHY (HE)	22.40	5.86	5.18
OVERWEIGHT (OW)	27.38	7.98	5.86
OBESE (OB)	33.34	7.14	5.60
MORBIDLY OBESE (MB)	46.28	8.14	6.39