Implementation and Prospective Evaluation of a Machine Learning-based Early Warning System For Multidrug-resistant Organisms

Vasin Vasikasin[1,2], Ashleigh Myall [2,3], Chang Ho Yoon[3,4], Kasom Bhangananda[1], Robert Peach [3], Dhitiwat Changpradub[1], Mauricio Barahona[2], Timothy Rawson[2], Worapong Nasomsong[1], Alison Holmes[2]

1 - Phramongkutlao Hospital, Bangkok, Thailand; 2 - Imperial College London, London, United Kingdom; 3 - NEX Health Intelligence Ltd, London, United Kingdom; 4 - University of Oxford, Oxford, United Kingdom.

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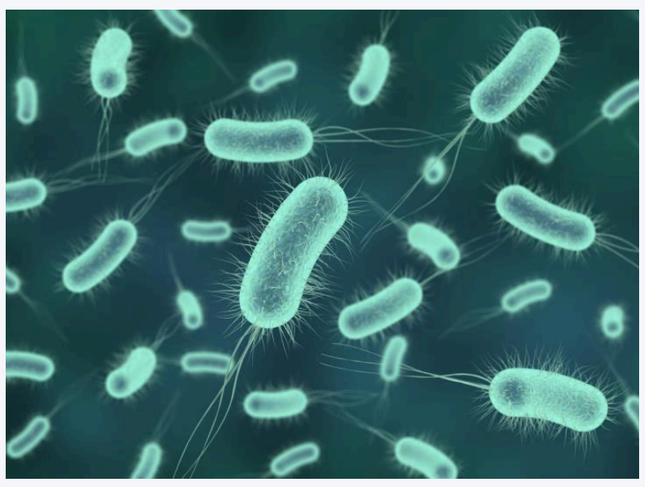
Background

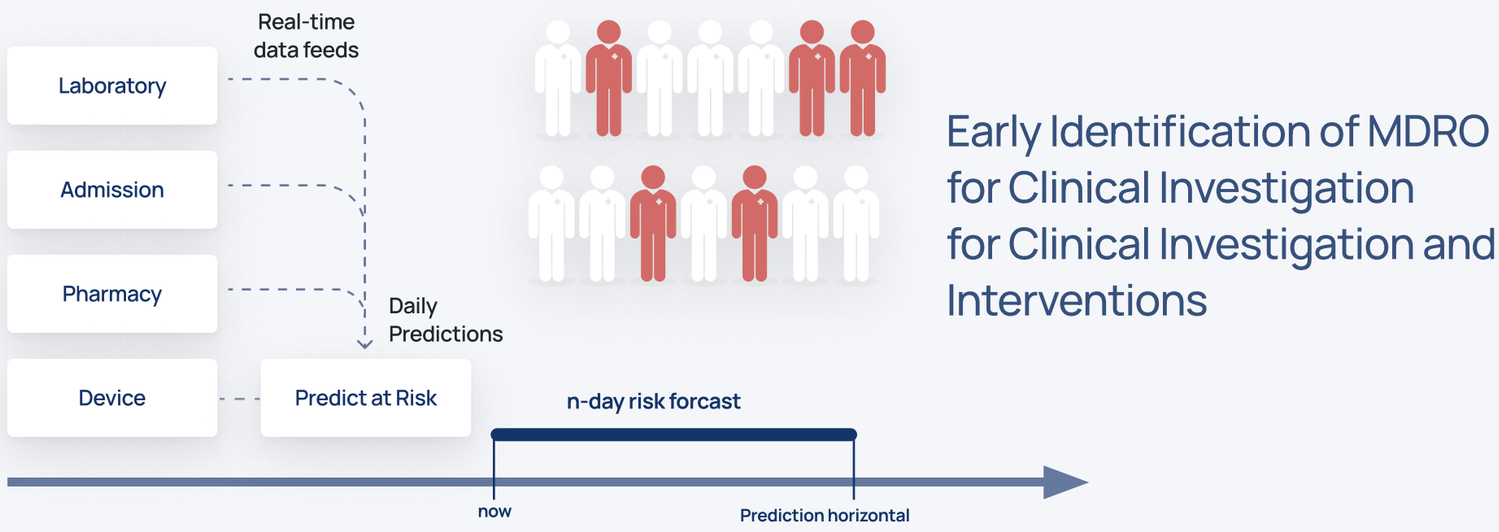
While retrospective prediction of multidrug-resistant organisms (MDROs) is well documented, prospective evidence remains limited. This study implemented and evaluated a machine learning-based system to prospectively identify patients at risk of MDRO colonisation or infection before microbiological confirmation.



Methods

The MDRO detection system (Figure 1) was deployed at a 1200-bed university hospital in Thailand, integrated in real-time with the electronic health records (EHR). It was trained on historical data (1/1/2023–31/8/2024; 39,223 admissions) to predict 7-day risk of colonisation/infection with extended-spectrum β-lactamase (ESBL)-producing Enterobacterales, carbapenem-resistant Enterobacterales (CRE), carbapenem-resistant A. baumannii or P. aeruginosa (CRAB/CRPA), methicillin-resistant S. aureus (MRSA), and vancomycin-resistant Enterococci (VRE). Prospective data collection began 1/9/2024 using live EHR feeds (microbiology, pharmacy, admissions) to generate daily predictions, which were evaluated against available microbiological results.

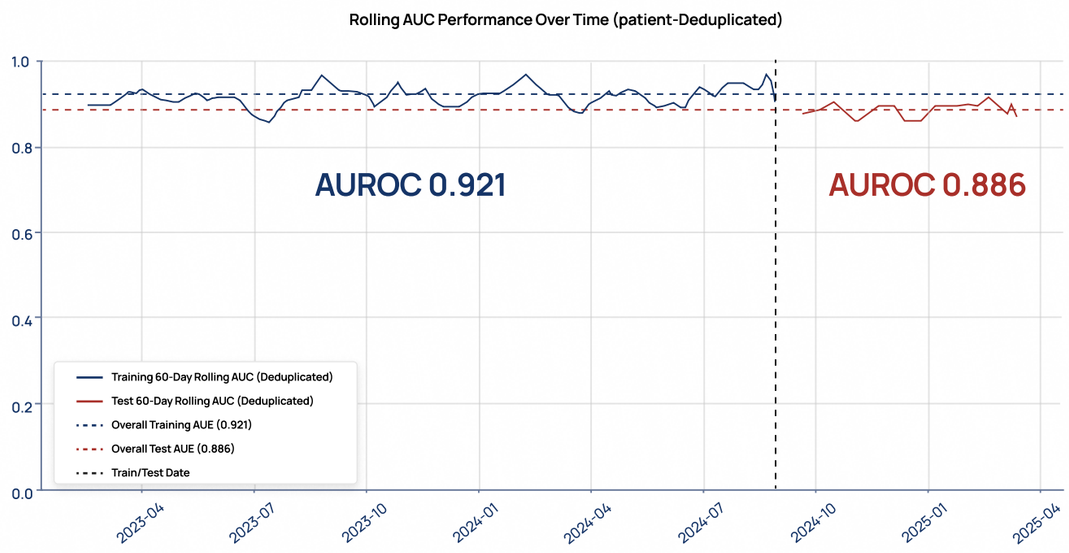
Figure 1. Overview of the MDRO early detection system. Real-time data feeds from the electronic health record (EHR)—including laboratory, pharmacy, admission, and device data—are used to generate daily predictions of patient-level risk of colonisation or infection with multidrug-resistant organisms (MDROs). The system provides a 7-day risk forecast to enable earlier investigation and targeted infection control interventions.



Results

Predictive performance post-training remained robust for CRE, VRE, and CRAB/CRPA (AUC-ROC >0.82), with CRE at 0.89 (Figure 2). The CRE model's performance dropped marginally from 0.92 to 0.89 in AUC-ROC. Key CRE predictors included catheter days, contact with CRE patients, and hospital stay duration (Figure). MRSA and ESBL performance was lower (0.70 and 0.65 AUC-ROC), likely due to the absence of a local screening programme.

Figure 2. Rolling 60-day AUC-ROC for CRE prediction using the MDRO detection system. Model performance remained stable during training (AUC-ROC 0.921) and generalised well during the prospective evaluation period (AUC-ROC 0.886). The slight decline highlights a consistent, high-performing model across both retrospective and real-time collection settings.



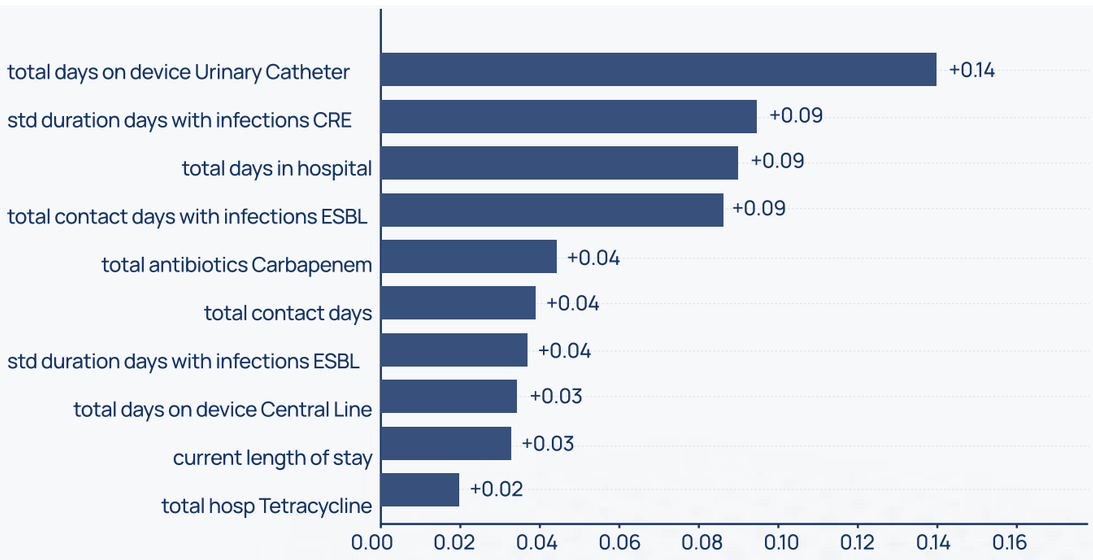


Figure 3. Top 10 contributing factors to positive CRE prediction based on SHAP analysis. The strongest predictors included total days on a urinary catheter, duration of contact with CRE-positive patients, and total hospital stay. These features reflect both exposure risk and healthcare-associated transmission dynamics.

Results Continued

Table 1. Predictive performance of the MDRO detection system during the training (1/1/2023–31/8/2024) and prospective testing period (post 1/9/2024), reported as AUC-ROC. CRE, VRE, and CRAB/CRPA maintained strong generalisability in prospective evaluation (AUC-ROC ≥ 0.83), while ESBL and MRSA showed reduced performance due to the absence of a routine surveillance programme.

Condition Label	Training Period (1/1/2023-31/8/2024) AUC-ROC (2dp)	Testing Period (post 1/9/2024) AUC-ROC (2dp)	Generalizability to Future Decrease in AUC-ROC (2dp)
CRE	0.92	0.89	0.03
VRE	0.94	0.85	0.09
CRPA/CRAB	0.88	0.83	0.05
ESBL	0.84	0.71	0.13
MRSA	0.85	0.65	0.20

Conclusion

This proof-of-concept deployment demonstrates that machine learning can provide early MDRO warnings in acute care. Daily predictions allow up to 7-day foresight for high-risk patients, enabling proactive infection control. Future steps include extended evaluation and validation in previously non-screened cohorts.

For more detail