



Artificial intelligence-based healthcare-associated bloodstream infection surveillance and classification system

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Introduction

- Central line-associated bloodstream infections (CLABSI) are a significant healthcare concern, with the potential to cause prolonged hospital stays, increased costs, and increased risk of mortality.
- However, identifying CLABSIs is a labor-intensive process, and performance depends on the expertise of infection control personnel (ICP).
- This study aims to develop a web-based system integrated with AI to detect and classify CLABSIs automatically to improve efficiency and accuracy.

Methods

- The Research Ethics Committee of Chung Shan Medical University Hospital approved the study (No. CS2-23009).
- A rule-based AI was developed to detect CLABSIs from structured data, such as vital parameters, and processed data based on the surveillance definitions defined by the Taiwan Centers for Disease Control in 2018.
- The initial detection performance was evaluated by comparing it to ICP-based surveillance results, and any inconsistencies were peer-reviewed to verify the accuracy and confirm the detection performance.

Results

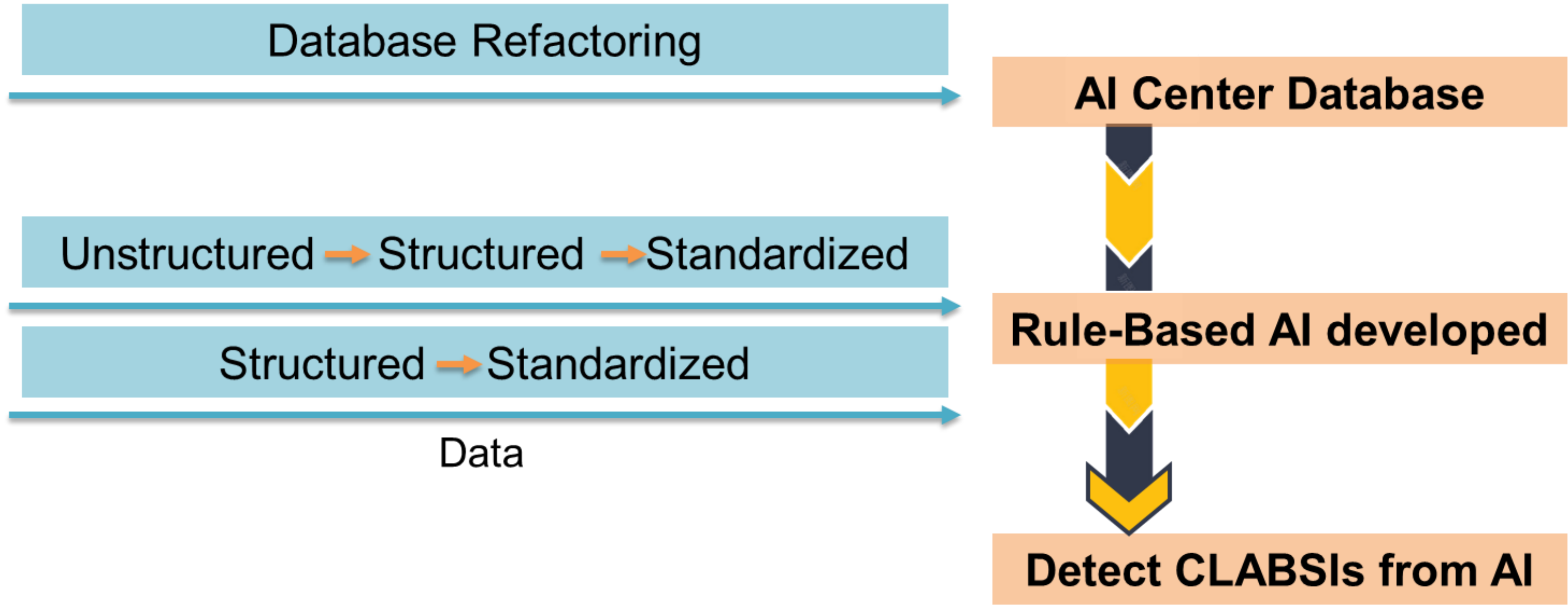


Figure 1. Developed a web-based system that extracts and organizes clinical data of inpatients from various subsystems of the hospital information system.



Figure 2. Structuring the content of the laboratory reports.

- First, an additional module was developed to standardize the data (identifying the name, placement, indication, and access of central lines from the catheter records).
- Next, natural language processing was applied to identify the pathogens from laboratory reports and signs or symptoms from nursing records (standardizing the diverse symptom description in Chinese or English and typos).
- Finally, a rule-based AI was developed.



Figure 3. Rule-Based AI system for detecting CLABSIs from structured data.

- A total of 22,961 samples from 9,173 inpatients were positive blood specimens, triggering the surveillance and classification procedure. According to the ICP-based results, 299 samples (1.3%) from 262 inpatients were identified as CLABSI.
- After peer review, we corrected 73 false positive (FP) as CLABSI, indicating the TP increased from 291 to 364. The sensitivity, specificity, positive predictive value, and negative predictive value (NPV) of the final AI system's performance were 97.85%, 99.11%, 64.65%, and 99.96%.

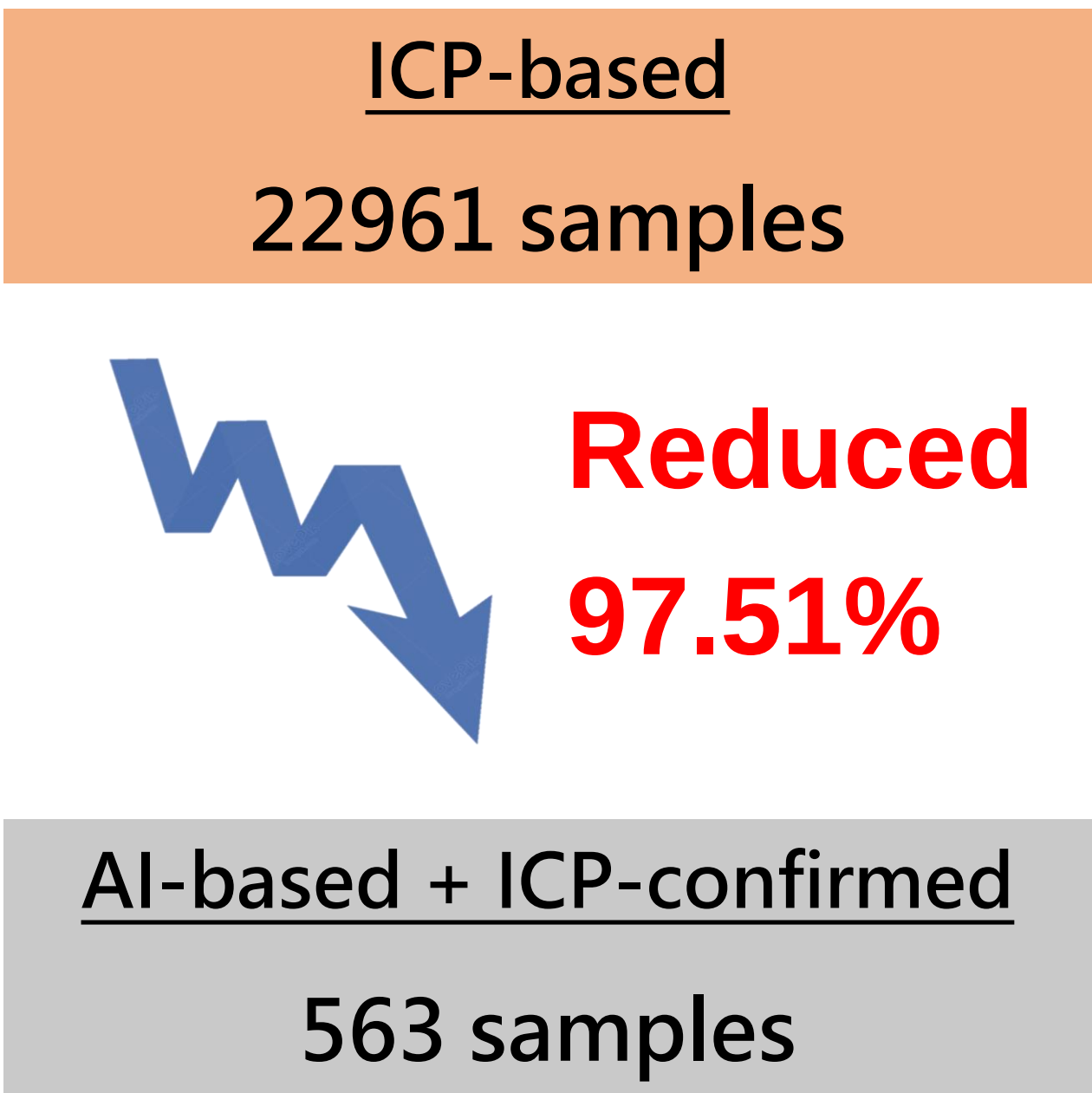


Figure 4. Reduction in samples needed for ICP-confirmation after AI implementation.

Confusion Matrix		ICP		
		Uninfected	Infected	
BSI AI	Uninfected	TN 22,390	FN 8	NPV 0.9996
	Infected	FP 272	TP 291	PPV 0.5169
		Specificity 0.9880	Sensitivity 0.9732	Sample size 22,961

Figure 5. Comparing the ICP-based and AI surveillance results for CLABSI and non-CLABSI.

Confusion Matrix		ICP		
		Uninfected	Infected	
BSI AI	Uninfected	TN 22,390	FN 8	NPV 0.9996
	Infected	FP 199	TP 364	PPV 0.6465
		Specificity 0.9911	Sensitivity 0.9785	Sample size 22,961

Figure 6. The consensus between ICP and AI for CLABSI and non-CLABSI after peer review.

Conclusion

Using an AI-based model with high negative predictive value could significantly reduce the labor-intensive of infection control personnel and improve the surveillance quality of central line-associated bloodstream infections (CLABSI). Speedy detection of CLABSI can aid in improving healthcare quality and cost-effectiveness.