EE550

The Potential Cost and Cost-Effectiveness Impact of Using Machine Learning Sepsis Prediction Algorithm for Early Detection of Sepsis in Intensive Care Units in Sweden and the United Kingdom

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SUMMARY AND CONCLUSIONS

- The study investigated cost impact and cost-effectiveness of a machine learning sepsis prediction algorithm (NAVOY) versus standard current practice in intensive care unit (ICU) settings in Sweden and the UK
- Data was generated based on a randomized, prospective clinical evaluation of NAVOY, literature sources and local price lists.
- In the base case, NAVOY predicted sepsis three hours prior to onset which resulted in incremental cost-effectiveness ratios (ICERs) well below thresholds in both Sweden and the UK.
- NAVOY was also associated with reductions in-hospital mortality, resulting in 356 and 1,469 lives saved per year in Sweden and UK, respectively.

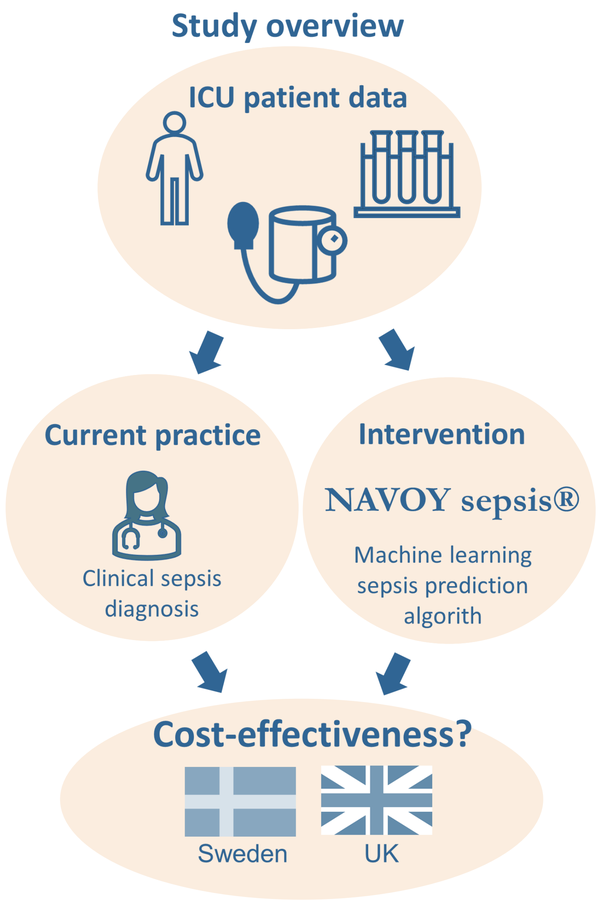
BACKGROUND AND OBJECTIVES

BACKGROUND

Early diagnosis of sepsis has been shown to reduce treatment delays, increase appropriate care, improve patient outcomes including reduced mortality [1-4]. Despite updated diagnostic criteria, early detection of sepsis is still complicated due to the lack of reliable biomarkers [5]. In practice, sepsis remains a clinical diagnosis made by combining information from physical examinations with laboratory data and information from monitoring devices. This procedure is time consuming subjective, and dependent on the skills and experience of the physician. Much of the same data, and more, that are now processed to make a sepsis diagnosis can be continuously collected at intensive care units (ICUs) and interpreted by a machine learning prediction algorithm (NAVOY sepsis®), which has shown excellent predictive properties in clinical settings [6].

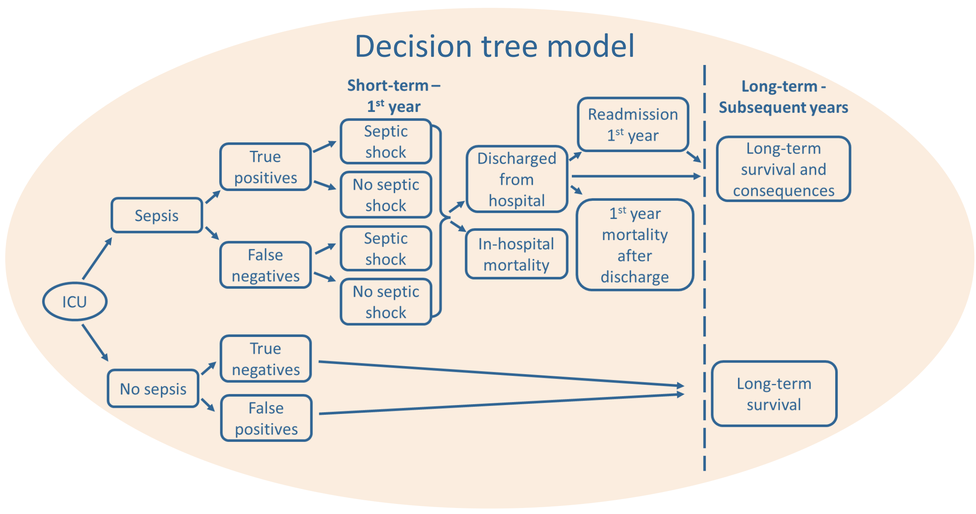
OBJECTIVE

The objective of this study was to, in ICU settings in Sweden and the UK, estimate the potential cost and cost-effectiveness impact of a machine learning algorithm forecasting the onset of sepsis.



METHOD

A decision tree model was developed to evaluate the cost-effectiveness and cost impact of the machine learning algorithm. The model was based on findings from a randomized, prospective clinical evaluation of the machine learning algorithm from literature sources and local price lists [7-8]. Of particular interest is to model the relationship between time from sepsis onset to treatment and prevalence of septic shock and in-hospital mortality. The model base case assumes that the time to treatment coincides with the time to detection and that the algorithm predicts sepsis three hours prior to onset. Cost-effectiveness is evaluated versus clinical practice methods in Sweden (Sepsis-3 criteria) and in the UK (NEWS2) [4, 9].



RESULTS

DETERMINISTIC BASE CASE RESULTS (per patient in ICU)

	PER ICU PATIENT Sweden			PER ICU PATIENT UK		
	Machine learning	Current practice	Incremental	Machine learning	Current practice	Incremental
Outcomes						
Length of stay (days in ward)	6.45	6.66	-0.21	6.45	6.66	-0.21
Length of stay (days in ICU)	1.62	1.78	-0.16	1.62	2.13	-0.51
Readmissions %	20.0	19.8	0.2	20.0	19.8	0.2
In-hospital mortality %	2.8	3.7	-1.0	2.8	3.6	-0.9
Life years (discounted)[1]	10.14	10.08	0.06	9.84	9.78	0.06
QALYs (discounted)[1]	7.11	7.07	0.04	6.88	6.84	0.04
Costs						
Sepsis prediction algorithm	1,037 €	-	1,037 €	1,037 €	-	1,037 €
Hospitalization (ward)	4,035 €	4,169 €	-134 €	2,082 €	2,150 €	-68 €
Hospitalization (ICU)	10,322 €	11,331 €	-1,009 €	2,575 €	3,383 €	-807 €
Readmission	835 €	826 €	8 €	938 €	929 €	9 €
Long-term consequences	208 €	186 €	22 €	203 €	183 €	20 €
Total costs	**16,436 €**	**16,512 €**	**-76 €**	**6,836** €	**6,645** €	**191** €
ICER			**- 1,783 €**			**4,832 €**

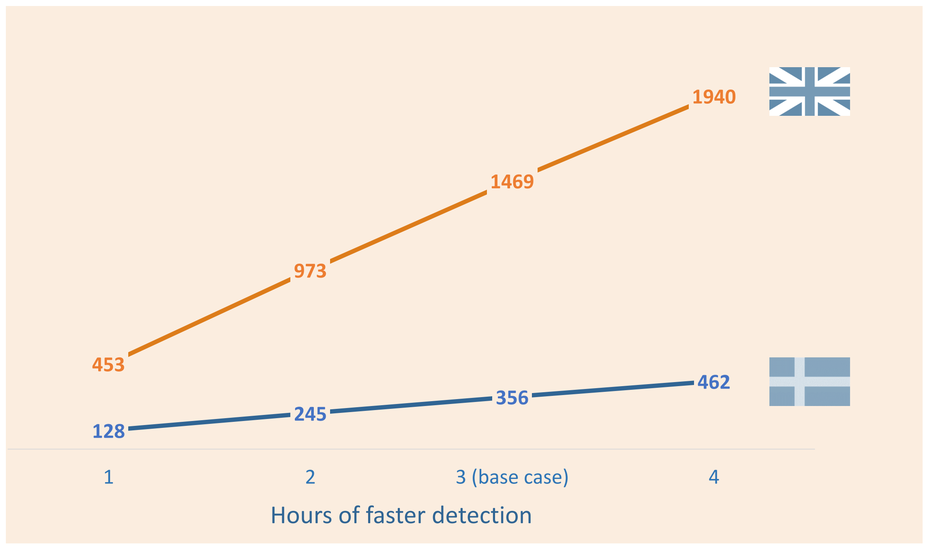
[1] The discount rate is 3.0% in Sweden and 3.5% in the UK.

- The prediction algorithm resulted in less time spend in hospital and reduced hospital mortality.
- The ICER was negative in Sweden (-1,783 €) indicating cost savings relative to current practice in Sweden only. The ICER in the UK was 4,832 € due to a minor increase in costs and QALYs gained.
- ICERs were below cost-effectiveness thresholds in both Sweden (~100,000 €) and the UK (~25,000 €).
- The cost of the prediction algorithm (1,037 €) was to a large extent offset by cost savings from shorter stays in the ICU.

STOCHASTIC SENSITIVITY ANALYSIS

		Base case	Incidence			Sensitivity/specificity			ICU and ward cost	
			30%	20%	10%	SoC 80/48%	SoC 84/37%	NAVOY 84/79%	+25%	-25%
Mean € (95% CI)	SWE	-76 (-791, 473)	-825 (-2,165, 249)	-359 (-1,409, 392)	127 (-359, 517)	-1 736 (-2,419, -1,189)	-2 310 (-3,029, -1,766)	217 (-465, 759)	-389 (-1,257, 285)	225 (-255, 621)
	UK	187 (7, 344)	109 (-279, 404)	149 (-99, 349)	216 (59, 353)	331 (160, 475)	187 (-10, 349)	258 (50, 426)	-30 (-289, 179)	407 (271, 522)
Mean QALYs (95% CI)	SWE	0.04 (0.01, 0.08)	0.09 (0.03, 0.16)	0.06 (0.02, 0.11)	0.03 (0.01, 0.05)	0.04 (0.01, 0.08)	0.04 (0.01, 0.08)	0.05 (0.02, 0.09)	0.04 (0.02, 0.08)	0.04 (0.01, 0.08)
	UK	0.04 (0.01, 0.07)	0.08 (0.02, 0.16)	0.05 (0.02, 0.11)	0.03 (0.01,0.06)	0.04 (0.01, 0.07)	0.04 (0.01, 0.07)	0.04 (0.02, 0.08)	0.04 (0.01, 0.08)	0.04 (0.01, 0.08)
ICER per QALY	SWE	-1,783	-9,372	-6,077	4,214	-41,880	-57,261	4,697	-9,012	5,482
	UK	4,832	1,357	2,661	8,019	8,082	4,811	5,940	-788	10,438
% cost <€0 (cost saving)	SWE	57	91	79	29	100	100	23	82	16
	UK	2	24	12	1	0	3	1	57	0
Percent <€20,000 threshold	SWE	94	100	97	85	100	100	87	98	88
	UK	96	98	98	87	90	94	95	98	85
Percent <€50,000 threshold	SWE	99	100	100	98	100	100	98	100	98
	UK	99	100	100	97	99	99	100	100	98

LIVES SAVED DEPENDING ON FASTER DETECTION



- The aggregated national figures implies that a three-hour faster detection implies a reduced in-hospital mortality, resulting in 356 and 1,469 lives saved per year in Sweden and UK, respectively.

- Stochastic cost-effectiveness analyses showed that the machine learning sepsis prediction algorithm was a cost-effective treatment option in both Sweden and the UK, demonstrating ICERs well below an established threshold of €20,000 per QALY in most scenarios.
- Close to 100% of simulations were below a cost per QALY threshold of €50,000.
- The most sensitive parameters in Sweden were incidence, sensitivity and specificity inputs of the algorithm, and standard of care (SoC).
- In the UK, ICU and ward input costs have a large impact, together with the sensitivity and specificity inputs.

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