Supplementary D: The early cost-effectiveness analysis with probabilities, cost, and effectiveness

The early cost-effectiveness analysis is conducted to estimate the cost-effectiveness of the ML model when compared to usual care. The part of the decision tree containing the ML model alternative is built after a test-based approach described by Tamlyn et al. [31]. Firstly, the ML model alternative is divided into two, illustrating the probability of the ML model predicting a patient to be at a high risk of HAB development or not. If the ML model indicated a high risk of HAB development, the tree was divided further into true positive and false positive cases, indicating that the model will not predict correctly in every case. After true positive and false positive cases, the tree splits into two branches illustrating the probability of PVC initiation during admission. For true positive cases, the tree is expanded into two, illustrating the probability that the patient develops HAB from the use of PVC. For cases where HAB was expected to develop from PVC, the tree is divided into two final branches indicating if the patient develops HAB or not based on the preventive treatment. For false positive cases, the tree is again divided into PVC initiation or not, hereafter all patients do not experience HAB due to their false positive label. For usual care, the tree is held simple to illustrate the probability of a patient being initiated on PVC or not, and the probability of developing HAB or not during hospital admission.

Probabilities

The probability estimates of the test performance of the machine learning (ML) model were calculated based on the true positive (TP)-, true negative (TN)-, false positive (FP)-, and false negative (FN) rates of the ML model with the best performance. ~14 % of all hospital-acquired bacteremia (HAB) cases may be associated with using peripheral venous catheters (PVC) [8,21], and

~70 % of all admitted patients have a PVC [1]. The probability of experiencing HAB in usual care is the same as for the ML model alternative.

Costs

The ML model is estimated to apply to 69,280 patients yearly, half the study cohort representing a two-year period. The analysis adopted a Danish hospital sector perspective and included the following costs: development, implementation, maintenance, and staff training costs related to the ML model, costs associated with the preventative, frequent intravenous catheter change, and PVC replacement during admission, and costs related to a HAB and general admission. The initial and capital costs of developing, implementing, training, and for maintenance were divided by the total number of patients the ML model may apply to. The ML model was estimated to be in service for five years.

Costs related to the preventative treatment were calculated based on time used by the nurse to judge the action after the ML model indicated a high-risk patient, nurse salary, time used by nurses to change the intravenous catheters, the price of a catheter, and frequency of intravenous catheter change. The hourly salary of nurses was calculated as effective hours, with an assumed total number of effective hours of 94 each month, aligning with the recommendation from The Danish National Health Technology Council [28]. A total aggregated cost estimate of experiencing a HAB during hospital admission versus not experiencing HAB is used and based on estimates from the Business Intelligence and Analysis Unit in North Denmark Region.

Effectiveness

The effectiveness was calculated by inserting the probability of dying from a HAB infection into the decision tree at those terminal nodes where HAB development was specified. This allowed us to calculate the expected effectiveness, as the average probability of dying from a HAB-related infection

in the ML model alternative and the usual care alternative, respectively. The probability of dying from a HAB infection in the study cohort was 26.89 %. The effect measure was inverted in the incremental cost-effectiveness ratio (ICER), since HAB-related death is an undesirable outcome. Table D presents the input estimates for populating the model and performing the early cost-effectiveness analysis:

Tabel D: the input estimates for populating the model and performing the early cost-effectiveness analysis.

Variable	Base-case value	Range	Reference for base-case value
Number of days admitted for cases with HAB (days)	30.56	11-37,7	Descriptive statistics over study cohort
Number of days admitted for cases without HAB (days)	4.29	1-4,8	Descriptive statistics over study cohort
Number of positive predictions by the ML model	69	-	Descriptive statistics over study cohort
Number of negative predictions by the ML model	27,645	-	Descriptive statistics over study cohort
Number of FN	19	0-50	Performance test of the ML model
Number of FP	6,534	0-10,000	Performance test of the ML model
Number of TN	27,645-FP	0-30,000	Performance test of the ML model
Number of TP	69-FN	0-50	Performance test of the ML model
Number of yearly screened patients by the ML model	69,280	20,000-200,000	Descriptive statistics over study cohort
Effective hourly nurse salary (DKK)	455	355-555	The Danish National Health Technology Council [28]
Cost of a patient getting hospital-acquired bacteremia (DKK)	57,542	30,000-120,000	the Business Intelligence and Analysis Unit in North Denmark Region
Cost of admission without getting a hospital-acquired bacteremia (DKK)	3,782	1,000-20,000	the Business Intelligence and Analysis Unit in North Denmark Region
Costs (purchase, implementation, staff training) (DKK)	750,000	0-2,000,000	Assumption
Cost of a venflon	3.95	0.95-6.95	Hospital lookup
Yearly costs of ML model (updates, maintenance, electricity, training of new staff etc.) (DKK)	50,000	20,000-80,000	Assumption
Discount rate	0.035	0.02-0.05	Finansministeriet [33]
Probability of the study cohort with a PVC	0.70	0.50-0.90	Literature suggestions [23]
Probability of HAB	0.0024	--	Calculated from TP, FP, TN, and FN.
Probability of HAB after preventative care for true positive cases	0.86	0.86-0.94	Literature suggestions [8,22]
Probability, high-risk HAB, predicted by the ML model	0.1941	--	Calculated from TP, FP, TN, and FN.
Probability of negative predictive value	0.9985	--	Calculated from TP, FP, TN, and FN.
Probability of positive predictive value	0.0068	--	Calculated from TP, FP, TN, and FN.
Probability of HAB-related death	0.2689	0.20-0.34	Descriptive statistics over study cohort
Hours between routine replacement of PVC	96	24-192	Literature suggestions [9]

Hours between clinically indicated replacement of PVC	168	72-264	Hospital lookup
Time used by a nurse to interpret the positive ML model prediction result (minutes)	2	0.5-5	Assumption
Minutes used by a nurse during a venflon change	10	3-25	Expert knowledge
The number of years the ML model is expected to be used	5	1-15	Assumption