Application of Multiple Neural Networks to Time Sequence Data - Prediction of Nosocomial Infection in Intensive Care Unit Patients -

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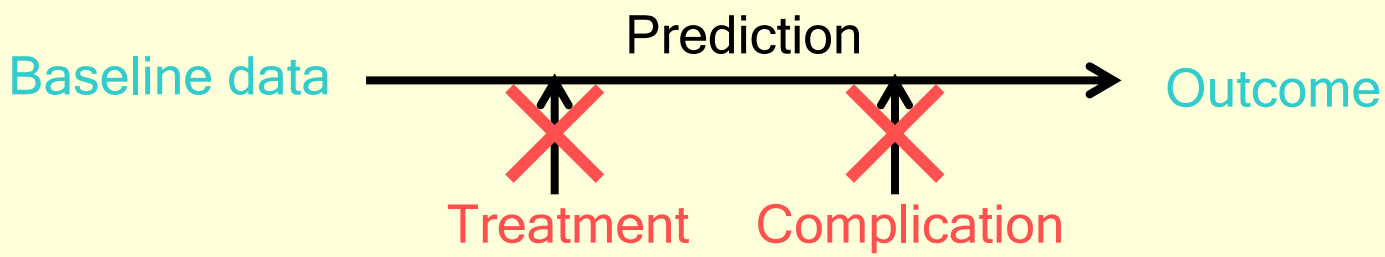
Background

- Multivariate regression models, particularly logistic regression, have commonly been used to estimate probabilities of outcome events.
- The predictors are usually selected from baseline data.
- Accordingly, the developed predictive models take no account of subsequent events, which may affect the patient's outcome.

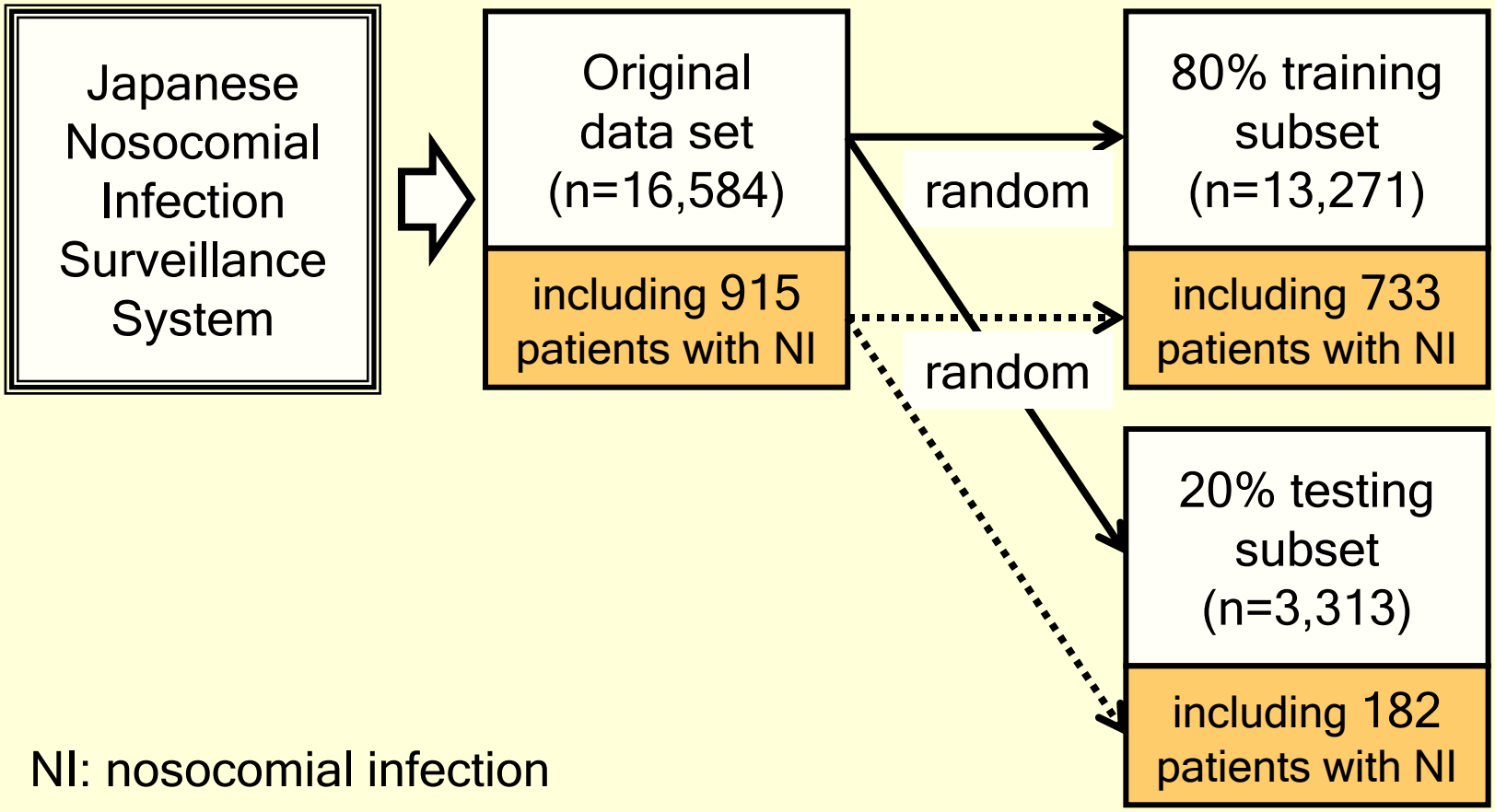


Objective

- We have invented the method of modeling time sequence data for prediction using multiple neural networks (NNs).
- The model was designed to use baseline data and subsequent events for estimating the probability of the outcome event - nosocomial infection in intensive care unit patients.
- We compared the predictive performance of multiple NNs with that of logistic regression and single NN using the cross-validation method.

Methods (1)

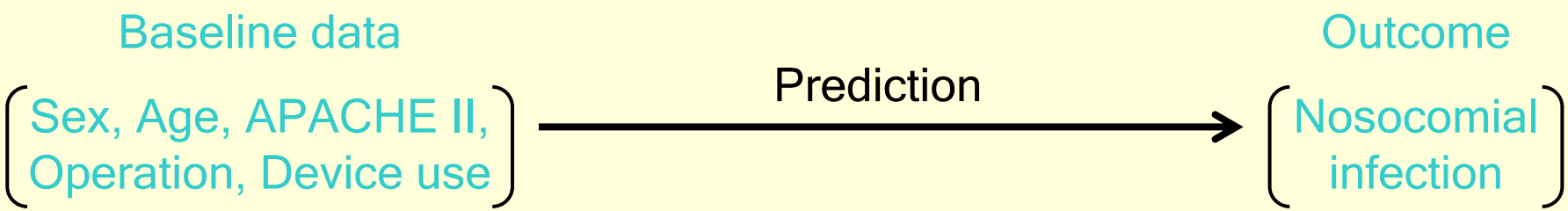
- Preparation of data sets (cross-validation)



NI: nosocomial infection

Methods (2)

- Development of three predictive models
  - Logistic regression
  - Single NN



  - Multiple NNs

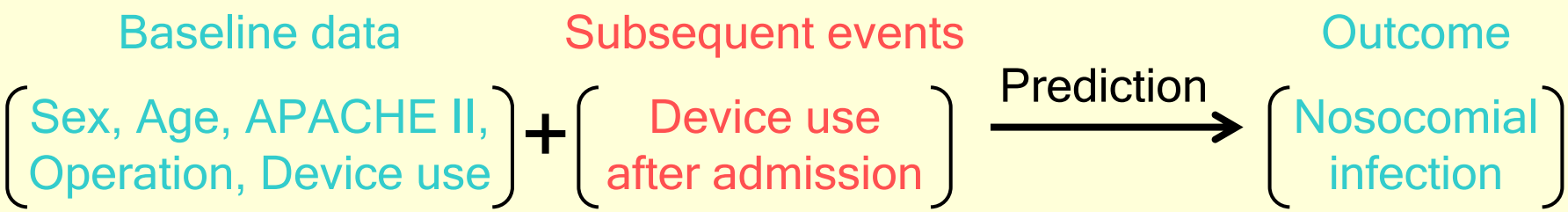
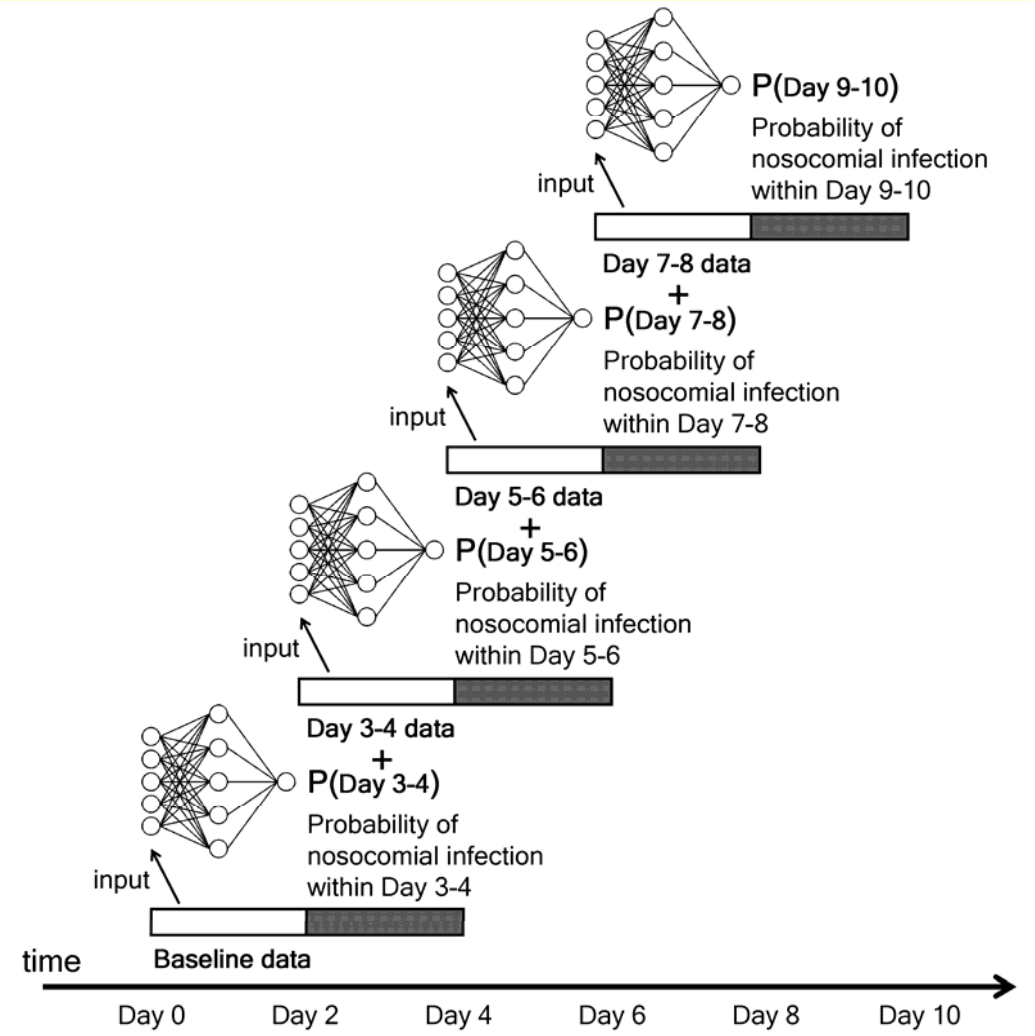
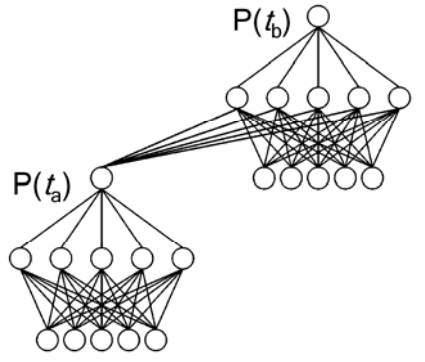


Figure 1 - Multiple NNs





Estimates for period t_a, P(t_a) were passed forward to a subsequent network as inputs and used to enhance estimates for the following period t_b, P(t_b).

Methods (3)

- Assessment of predictive performance
  - Total classification accuracy (TCA)

    A proportion of correctly classified cases.
  - The area under a ROC curve (AUC)

    A trade-off between sensitivity and specificity.

Table 1 - Classification accuracy

	Total (TCA)	Positive (sensitivity)	Negative (specificity)
Logistic regression	0.63	0.71	0.62
Single NN	0.37	0.85	0.35
Multiple NNs	0.73	0.92	0.72

Multiple NNs showed the highest classification accuracy for total (TCA), positive (sensitivity), and negative (specificity) cases.

Figure 2 - ROC curves

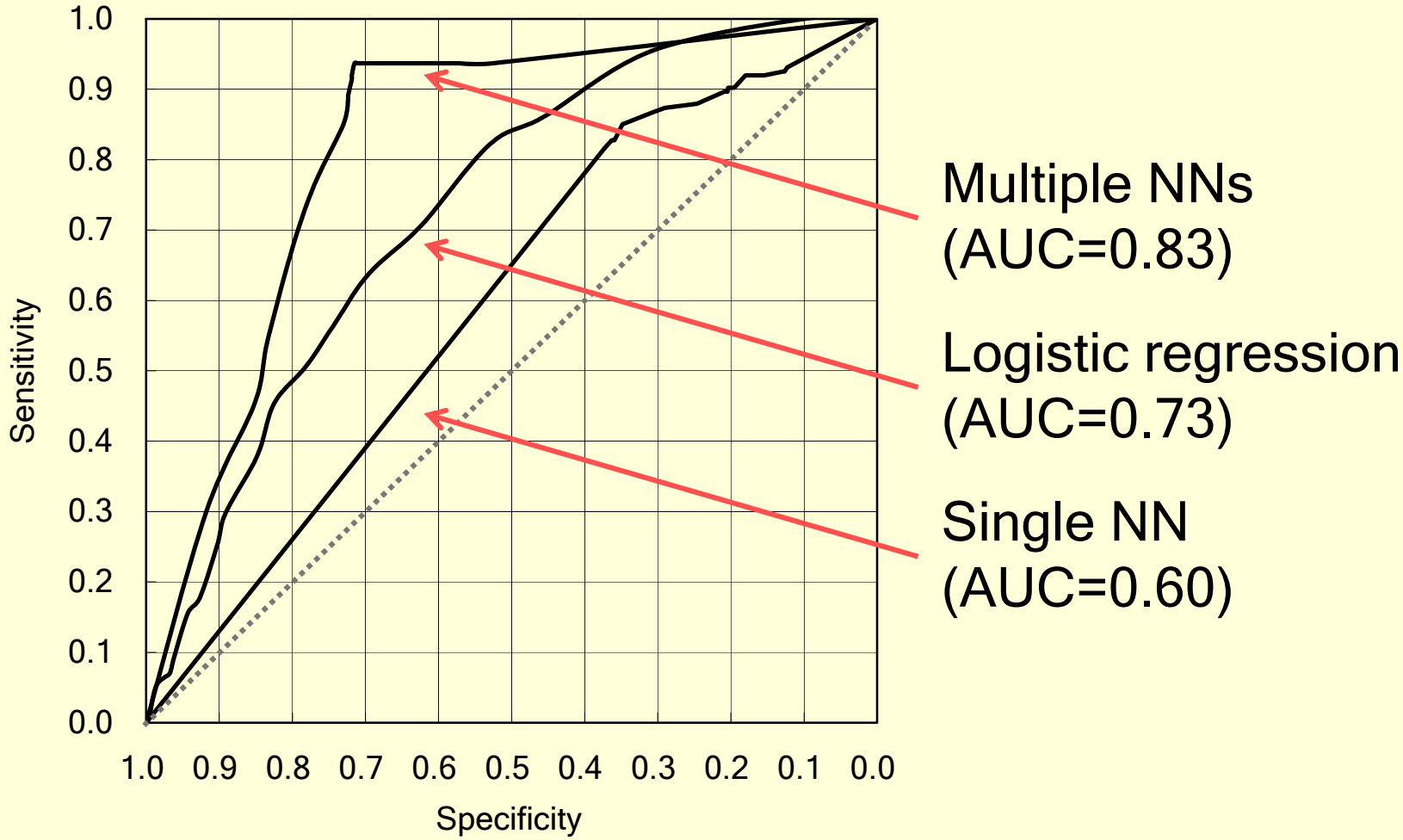


Table 2 - Predictive performance by period

		Day 3-4	Day 5-6	Day 7-8	Day 9-10
Number of patients (positive cases)		1625 (68)	610 (51)	292 (34)	612 (21)
Logistic regression	TCA	0.75	0.61	0.52	0.38
	AUC	0.79	0.73	0.67	0.62
Single NN	TCA	0.43	0.37	0.33	0.25
	AUC	0.63	0.58	0.55	0.55
Multiple NNs	TCA	0.73	0.66	0.79	0.77
	AUC	0.86	0.77	0.84	0.82

Multiple NNs showed no significant change, whereas logistic regression and single NN showed noticeable declines in TCA and AUC.

Conclusion

- Multiple NNs outperformed logistic regression and single NN in the prediction of nosocomial infection in intensive care unit patients.
- The predictive performance of multiple NNs was kept at a constant level, whereas that of logistic regression and single NN decreased with increasing a follow-up period.

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