

## Background:

National early warning score (NEWS) seems to be the best screening tool to detect critically ill patients in the hospital surroundings and emergency medical service (EMS). Glucose homeostasis is disturbed in many critical patients and it is related to poor outcome. Our aim was to study, if blood glucose could be added to NEWS for better identification of patient in risk of death in prehospital setting.

## NEWSgluc score

Physiological parameters	3	2	1	0	1	2	3
Respiratory rate (/min)	≤8		9-11	12-20		21-24	≥25
SpO2 (%)	≤91	92-93	94-95	≥96			
Supplemental oxygen given		Yes		No			
Temperature (°C)	≤35		35.1-36.0	36.1-38.0	38.1-39.0	≥39.1	
Systolic blood pressure (mmHg)	≤90	91-100	101-110	111-219			≥220
Heart rate (/min)	≤40		41-50	51-90	91-110	111-130	≥131
Level of consciousness				A			V, P or U
Blood glucose (mmol/l)	≤3.0			3.1-11	≥11.1		

## Patients & Methods:

Patients over 18 years with documented vital signs to calculate NEWS values and a measured plasma glucose value were included in the study. Plasma glucose was categorized as normal (3.1-11.0 mmol/l), hyperglycaemia (≥11.1 mmol/l), or serious hypoglycaemia (≤3.0 mmol/l). Adding glucose to NEWS (NEWSgluc) was tested by multivariate logistic regression model. Based on odds ratios hypoglycaemia received 3, normoglycaemia 0, and hyperglycaemia 1 point. Discrimination of the model was done by area under the receiver operating curve (AUROC). Calibration was tested visually by Hosmer-Lemeshow test. Next models were compared using likelihood ratio tests (LRTs). Reclassification was tested using both continuous net reclassification index (cNRI) and integrated discrimination index (IDI), and last risk analysis was done by non-parametric local regression against the original NEWS score.

## Data collection:

Data was collected retrospectively by utilizing electronic EMS data record system from 17 August 2008 to 19 December 2015. From 750.694 calls 27.141 had both complete NEWS measures and blood glucose measured. 24 hours and 30 days survival of the patients was followed from Population Register Centre.

## Results & Discussion:

Multivariable logistic regression model revealed good prediction with hypoglycaemic values [ 24 hours mortality: OR 5.46, (2.87-9.64) and for 30 days mortality: OR 2.33, (1.47-3.52) ] and moderately with hyperglycaemic values respectively [24 hours: OR 1.54, (1.11-2.12) and 30 days: OR 1.41, (1.20-1.66) ]. However, AUROC did not reveal better discrimination for mortality at 24 hours (an AUC for NEWSgluc model 0.870, (CI95% 0.846-0.894) and an AUC with NEWS alone model 0.864, (CI95% 0.839-0.888). Both the LRT (both p < 0.001) and cNRI showed better identification of mortality risk if glucose was included in the score: at 24 hours cNRI was 0.413 (CI95% 0.281-0.545) and at 30 days 0.254 (CI95% 0.197 -3.11). However, at 24 hours IDI was not statistically significant (0.004, CI95% 0.000-0.008) but was statistically significant at 30 days (0.002, CI95% 0.001-0.003). Risks per score point estimation and calibration model showed glucose added benefit to NEWS at short-term.

Considering the results from multivariable logistic regression models, we concluded with weighting the parameter estimates (logarithmic odds ratios) for normoglycemia, for hypoglycaemia, and for hyperglycaemia. Both the model with the NEWS variables with glucose categories (Table 3) and NEWS score with glucose categories were considered when weighting the glucose categories. As a result, we suggest that as an additional parameter in NEWS normoglycaemia (including moderate hypoglycaemia and hyperglycaemia) could receive 0 points, hypoglycaemia 3 point, and hyperglycaemia 1 points.

AUROC is widely used statistical method. However, it only investigates the discrimination ability of the model and completely ignores the accuracy of the predicted risks. Hence including model comparison, i.e. LRT, and risk reclassification measures, such as cNRI, with calibration of the models the performance of the additional parameter can be viewed more thoroughly.

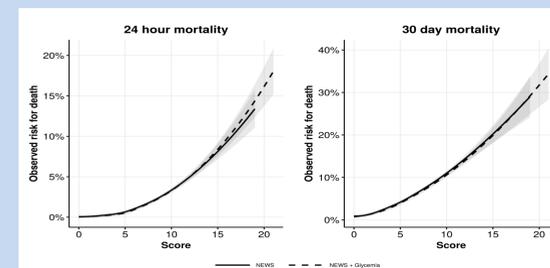


Figure 2. Loess regression plots for the NEWS score against the observed risk for mortality.

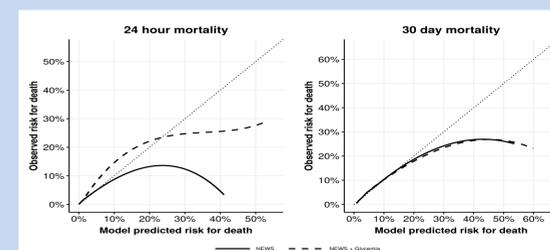


Figure 3. Calibration of models at 24 hours and at 30 days

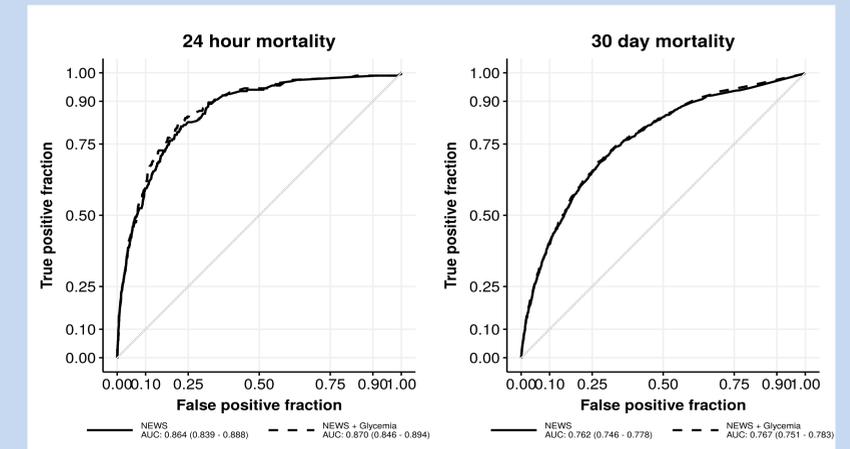


Figure 1. AUROC of 24 hour and 30 day mortality

## Conclusion & Perspectives:

Adding plasma glucose as an additional parameter to NEWS may improve mortality prediction. Especially presence of hypoglycaemia seems to add value in mortality prediction at short-term.

Further studies should be done with a prospective study design and external validation. A case control study, with diabetics and non-diabetics should be maybe studied to find out if these groups would have had differences.

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