Combining the Nurse Intuition Patient Deterioration Scale with the National Early Warning Score provides more Net Benefit in predicting serious adverse events : a prospective cohort study in medical, surgical, and geriatric wards

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ABSTRACT

Objectives

This prospective cohort study aimed to assess the predictive value of the Nurse Intuition Patient Deterioration Scale (NIPDS) combined with the National Early Warning Score (NEWS) for identifying serious adverse events in patients admitted to diverse hospital wards.

Research Methodology/Design

Data was collected between December 2020 and February 2021 from a 350-bed acute hospital near Brussels, Belgium. The study followed a prospective cohort design, employing NIPDS alongside NEWS for risk assessment. Patients were monitored for 24 hours post-registration, with outcomes recorded.

Setting

The study was conducted in a hospital with a Rapid Response System (RRS) and electronic patient records wherein NEWS was routinely collected. Patients admitted to two medical, two surgical, and two geriatric wards were included.

Main Outcome Measures

The primary outcome included death, urgent code calls, or unplanned ICU transfers within 24 hours after NIPDS registration. The secondary outcome comprised rapid response team activations or changes in Do-Not-Resuscitate codes.

Results

In a cohort of 313 patients, 10/313 and 31/313 patients reached the primary and secondary outcome respectively. For the primary outcome, NIPDS had a sensitivity of 0.900 and specificity of 0.927, while NEWS had a sensitivity of 0.300 and specificity of 0.974. Decision Curve Analysis demonstrated that NIPDS provided more Net Benefit across various Threshold Probabilities. Combining NIPDS and NEWS showed potential for optimizing rapid response systems. Especially in resource-constrained settings, NIPDS could be used as a calling criterion.

Conclusion

The NIPDS displayed strong predictive capabilities for adverse events. Integrating NIPDS into existing rapid response systems can objectify nurse intuition, enhancing patient safety.

Implications for Clinical Practice

The Nurse Intuition Patient Deterioration Scale (NIPDS) is a valuable tool for detecting patient deterioration. Implementing NIPDS alongside traditional scores such as NEWS can improve patient care and safety. The optimal NIPDS threshold to activate rapid response is ≥5.

KEYWORDS

Critical Care Nursing

Hospital Rapid Response Team

Intuition

Medical-Surgical Nursing

Prospective Studies

Risk Management

INTRODUCTION

Early Warning Scores (EWS) are used as part of the afferent limb system in a Rapid Response System (RRS) to trigger a medical response when patients in the general wards show early signs of deterioration (Gerry et al., 2020). EWSs are, in most cases, scores that are calculated using a limited set of the patient's vital signs and have been previously validated to predict patient death, Cardiopulmonary Resuscitation (CPR), and Unplanned Intensive Care Unit (ICU) admissions (Gerry et al., 2020). Their goal is to standardise patient observations using an EWS and by doing so create a 'safety net' to detect deterioration early. When early deterioration is detected, nurses and/or physicians with critical care experience can reach out to the general ward, bringing their expertise to the patient in need (DeVita et al., 2017). Currently, the best performing EWS is the National Early Warning Score (NEWS) which was developed by the Royal College of Physicians (UK) and repeatedly externally validated (Brink et al., 2019,Hargreaves et al., 2020,RCOP, 2017,Sabir et al., 2021,Vergara et al., 2021). If an RRS is implemented effectively, patients in the general ward will be treated early or are receiving end-of-life care therefore possibly reducing the number of late unplanned ICU admissions and the length of stay on the ICU (Subbe et al., 2019). EWSs such as the NEWS seem to be good-performing screening instruments (Haegdorens et al., 2020). However, the NEWS guideline stresses that concern about a patient's clinical condition should always override the NEWS if the attending healthcare professional considers it necessary to escalate care (RCOP, 2017).

In previous research, we developed and validated a new scale to aid nurses in measuring patient deterioration through nurse intuition in medical and surgical patients admitted to the general ward (Haegdorens et al., 2023). The Nurse Intuition Patient Deterioration Scale

(NIPDS) was developed, piloted, psychometrically tested, and validated in this first study. The goal was to develop an instrument, based on current literature and expert review, that nurses could use at the patient's bedside and that includes clear predefined clinical cues. Additionally, we aimed for a scale that could be used for patients who could not (easily) respond to questions. The NIPDS seemed highly accurate in predicting physician assistance, resuscitation team calls, patient death, and unplanned transfers to the intensive/medium care unit within 24 hours after registration using a threshold of ≥ 5. However, it remains unclear how the NIPDS performs compared to the NEWS to predict patient outcomes and if both scores could be used simultaneously to increase accuracy.

METHODS

Objectives

This prospective cohort study aimed to investigate the predictive value of the Nurse Intuition Patient Deterioration Scale (NIPDS) in addition to the National Early Warning Score (NEWS) to predict serious adverse events in patients admitted to the general ward of an acute care hospital in Belgium.

Setting and population

This study was conducted in an acute care hospital near Brussels, Belgium. The hospital was a medium-sized 350-bed facility that included emergency services and a level-1 ICU with 9 beds in total.

The hospital had an RRS in place that includes a Rapid Response Team (RRT) responding to calls from nurses in the general ward. The Rapid Response Team consists of a physician on call with expertise in critical care. Within the RRS, the NEWS was calculated by nurses at the

patient's bedside using a spot-check monitor (i.e., mindray V9 vital signs monitor) that includes a thermometer located on the side of the device. This device automatically calculates the NEWS when all parameters have been measured and displays the required action according to hospital protocol. To calculate the NEWS, all six vital signs are required including the administration of oxygen. If any of these seven parameters are incomplete, the device will not calculate a NEWS. The monitor is connected to a server via Wi-Fi, which automatically sends all data to the electronic patient record.

The NEWS is registered at admission and at least once every 8 hours on all study wards. In practice, nurses register the NEWS at the beginning of each shift (8am, 2pm, and 10pm). In surgical patients, the NEWS is calculated every 4 hours during the first 24-hours after surgery. After that, the standard protocol is followed (every 8 hours). The observation frequency depends on patient acuity (determined by the NEWS level) and can be adjusted in consultation with the responsible physician after clinical assessment of the patient by the attending nurse.

In the study hospital, nurses are assigned to a specific ward, and within this ward, all nurses take responsibility for all admitted patients. No system is in place that could assign nurses with a specific experience to patient care. Patients admitted to two medical, two surgical, and two geriatric wards were eligible for inclusion in this study from December 2020 until February 2021. COVID-19-wards were excluded from participation because of the specific pathology, and since it was unfeasible to implement at that time because of the COVID-19 pandemic. Convenience sampling was used to include all adult patients admitted to participating wards. Minors and patients who actively refused participation were excluded.

Instruments

The NIPDS is an instrument designed and validated to be used by nurses to assess patient deterioration including 9 items: the patient is less able to verbally express themselves, feeling unwell, has altered facial expressions, is lethargic, restless, has a change in behavior, has an altered skin color (pale, red, yellow, grey), has a staring and/or penetrating gaze, and is less responsive (Haegdorens et al., 2023). The instrument is completed by scoring each of the items on a 3-point Likert scale ranging from not present to very present. In previous research it showed excellent construct validity and internal consistency and proved highly accurate in predicting urgent physician assistance, resuscitation team calls, patient death, and unplanned transfers to intensive/medium care.

Intervention and data collection

After a short information session of one hour on how to use the NIPDS, nurses were asked to fill in the scale during each patient admission when possible. The NIPDS could also be recorded during admission when nurses were worried about their patients. The NEWS and all demographic and administrative data were recorded as a part of standard operating procedures during admission. Patients were followed up during the 24 hours after each scale registration. All outcomes happening after 24 hours were therefore disregarded. Outcomes were recorded on the NIPDS forms and checked by JL using patient records. The primary outcome was a composite of death OR cardiopulmonary resuscitation call OR unplanned transfer to the ICU. The secondary outcome was a composite of a Rapid Response Team activation OR upscaling of a Do-Not-Resuscitation-code. Upscaling of a Do-Not-Resuscitation-code meant that some form of therapeutic limitation was initiated by the patient's treating physician (e.g., from DNR code 0, no limitation in therapy to DNR code 1, do not attempt

cardiopulmonary resuscitation). One patient could reach multiple outcomes (e.g., death following a cardiopulmonary resuscitation call after rapid response team activation). However, only one NIPDS and NEWS registration was included per patient meaning that the database contained no multiple observations per patient.

Data analyses

IBM's SPSS Statistics for Mac OS version 28 was used for basic statistical analysis (IBM Corp, 2023). To compare continuous variables between negative and positive NIPDS cohorts, an independent samples t-test or a Mann-Whitney U-test was used depending on the distribution of data. The normality of data distribution was checked using absolute values or z-scores according to the sample size following Kim's method (Kim, 2013). In the case of non-normal distributions, non-parametric tests were used. Proportions were compared using a Chi-Squared test or a Fisher exact test when the number in at least one cell is less than 5 for a 2x2 table (Pett, 2015).

Receiver Operator analyses were done to compare the NIPDS and NEWS performance in predicting the primary outcome. The maximum Kolmogorov–Smirnov metric and Youden's index were used to find the optimal scale threshold. Additionally, a multiple binary logistic regression model was fitted to calculate the risk of experiencing the primary outcome per one-point increase of the NIPDS. Variables showing a significant effect in univariate regression analyses were included in the final model using the ENTER-method. Goodness of fit of the final model was assessed using the coefficient of determination (Nagelkerke R-squared), and items not contributing to the model variance were excluded.

Finally, a Decision Curve Analysis (DCA) was carried out to calculate the usefulness of NIPDS in clinical practice. DCA is a statistical approach used to assess the practicality of a model or

diagnostic test in aiding clinical decision-making and to determine which of two models yields superior decision outcomes (Vickers and Elkin, 2006). Decision curves plot the Net Benefit on the y-axis and Threshold Probabilities on the x-axis (Vickers et al., 2019). The Net Benefit is calculated as a weighted combination of true and false positives divided by the sample size and illustrates the trade-offs between benefit (true positives) and harm (false positives) (Van Calster et al., 2018). The Threshold Probability represents the probability at which you would be willing to act on the model's predictions. Essentially, it's the point at which you decide that the potential benefits of using the model outweigh the potential harms or costs of false positives. For example, if a score predicting serious events in patients generates lots of false positives, it generates additional nursing tasks such as: increasing observation frequencies and rapid response calls. This could eventually increase nursing workload and strain as well. In clinical practice, it is important to know which instrument has the greatest benefit (detecting true positives) and what the trade-off is in clinical workload (the Number Needed To Treat/Evaluate).

Ethical considerations

Before the start of this study ethical approval by the institutional review board of the study site (IRB Algemeen Sint-Mariaziekenhuis Halle) was obtained. Moreover, this study was conducted in correspondence with the General Data Protection Regulation 2016/679 of the European Union (Krzysztofek, 2018). The researchers were never in contact with any patients. All NIPDS forms were registered by nurses working on the study wards and pseudonymized for data collection. No identification data of the participating nurses was collected. The intervention (registration of NIPDS) was carried out and supported by hospital

staff and directors as part of a quality improvement effort. Therefore, no a priori informed consent from patients was necessary in accordance with Belgian law. Patients were nonetheless extensively informed by their responsible nurses at admission. A poster with study information was available for patients and families and included the research team's contact information to answer any additional questions. Patients and their families were informed that they could opt out of this study at any time. If necessary additional information was given to patients and families by the ward managers who supported the implementation of the NIPDS in their ward.

RESULTS

In total 321 patients had a valid NIPDS registration during admission, and 8 were excluded resulting in 313 patients that were included for analysis. All NIPDS forms were filled in correctly, outcomes were checked by the research team using patient records provided by the hospital, and finally, full data were available for 313 patients. Of all registered NIPDS, 31 patients had a positive score (i.e., ≥5) (Figure 1). The primary outcome was reached in 9/31 patients (29,0%) and 1/282 patients (<1.0%) in the positive and negative NIPDS groups, respectively. The secondary outcome was reached in 21/31 (67,7%) and 12/282 (4,3%) patients in the positive and negative NIPDS groups, respectively. In the positive NIPDS group, 4/31 patients (12.9%) had a positive NEWS score (i.e., ≥5). Furthermore, in the negative NIPDS group, only 7/282 patients (2.5%) had a positive NEWS score (i.e., ≥5).

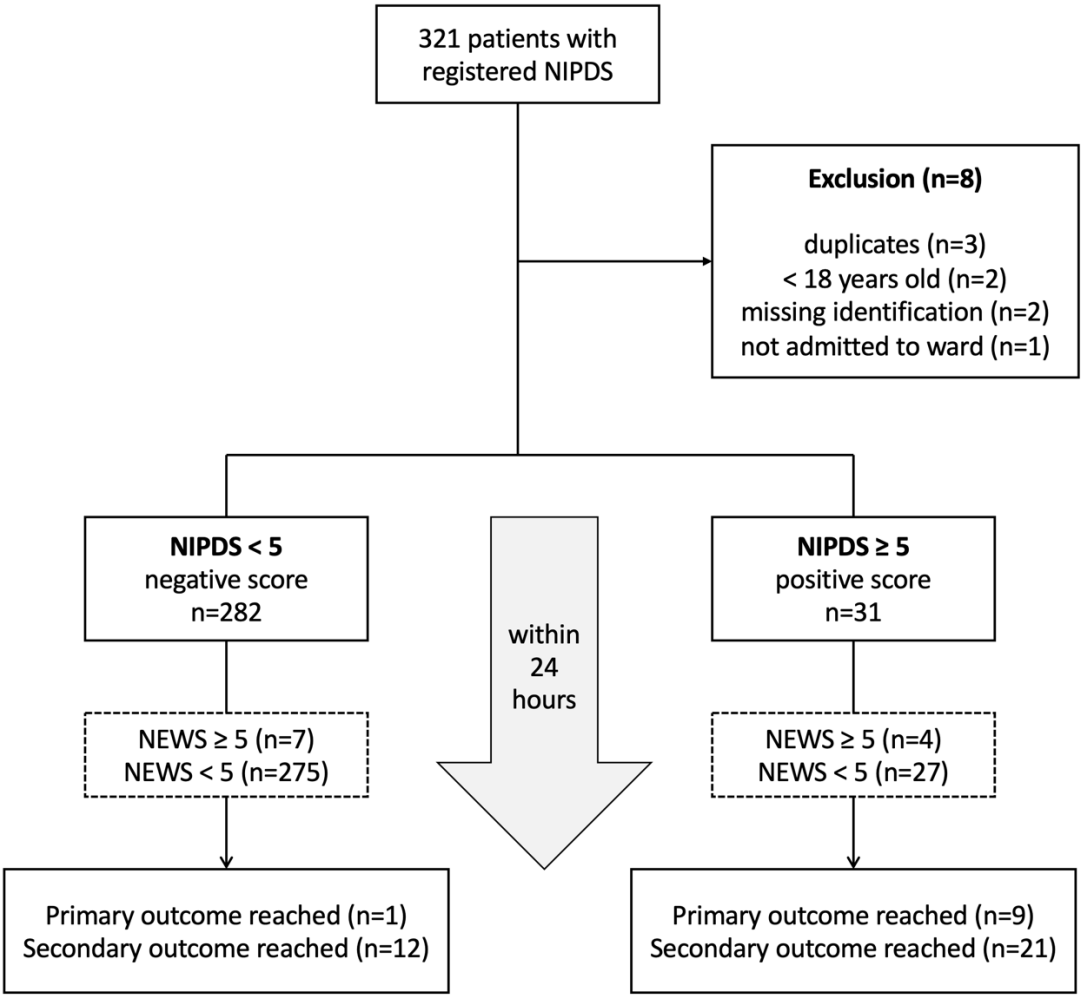


Figure 1. Flow diagram

In total, 53% of included patients were female, and the mean age was 69.3 (SD 16.8) (Table 1). In the positive NIPDS group, significantly fewer patients were emergency admissions (i.e., 90.3% of all patients with NIPDS ≥5 were planned admissions to the general ward). However, patients were older and had a higher NEWS score if they had a positive NIPDS at admission. The patients' NEWS scores showed a skewed distribution; therefore, non-parametric tests were used when comparing groups in Table 1. In general, significantly more patients experienced primary and secondary outcomes within 24 hours if they presented with a positive NIPDS.

	NIPDS		Total (n=313)	p-value
	negative (<5) (n=282)	positive (≥5) (n=31)		
Characteristics				
sex: female [%]	54.3	45.2	53.4	0.335 *
geriatric ward [%]	10.3	19.4	11.2	0.277 *
surgical ward [%]	68.8	58.1	67.7	
medical ward [%]	20.9	22.6	21.1	
emergency admission: yes [%]	75.5	9.7	69.0	<0.001 *
age [mean (SD)]	68.51 (16.90)	76.48 (14.11)	69.30 (16.79)	0.012 $
NEWS [mean (SD)]	1.14 (1.27)	2.63 (2.84)	1.28 (1.54)	0.002 #
Primary outcome within 24 hours				
a. death [% (n)]	0.4 (1)	9.7 (3)	1.3 (4)	0.003 §
b. urgent code call [% (n)]	0.0 (0)	9.7 (3)	1.0 (3)	<0.001 §
c. unplanned transfer to the ICU [% (n)]	0.0 (0)	16.1 (5)	1.6 (5)	<0.001 §
Primary outcome reached: a OR b OR c [% (n)]	0.4 (1)	29.0 (9)	3.2 (10)	<0.001 §
Secondary outcome within 24 hours				
d. rapid response team activation [% (n)]	2.8 (8)	67.7 (21)	9.3 (29)	<0.001 *
e. upscaling of a Do-Not-Resuscitation-code [% (n)]	1.4 (4)	19.4 (6)	3.2 (10)	<0.001 §
Secondary outcome reached: d OR e [% (n)]	4.3 (12)	67.7 (21)	10.5 (33)	<0.001 §

* Chi-Squared test; $ Independent samples t-test; # Mann-Whitney U-test; § Fisher exact test

Note: Patients could have had multiple outcomes (e.g., unplanned transfer to the ICU AND urgent code call). The sum of the different outcomes is therefore not equal to the total number reaching primary or secondary outcomes.

Table 1. Comparison of patient characteristics and outcomes between negative and positive NIPDS scores

Primary outcome:
death OR urgent code call OR unplanned transfer to the ICU

	Outcome reached (1)	Outcome not reached (0)
Positive NIPDS (1)	9	22
Negative NIPDS (0)	1	281

Secondary outcome:
rapid response team activation OR upscaling of a Do-Not-Resuscitation-code

	Outcome reached (1)	Outcome not reached (0)
Positive NIPDS (1)	21	10
Negative NIPDS (0)	12	270

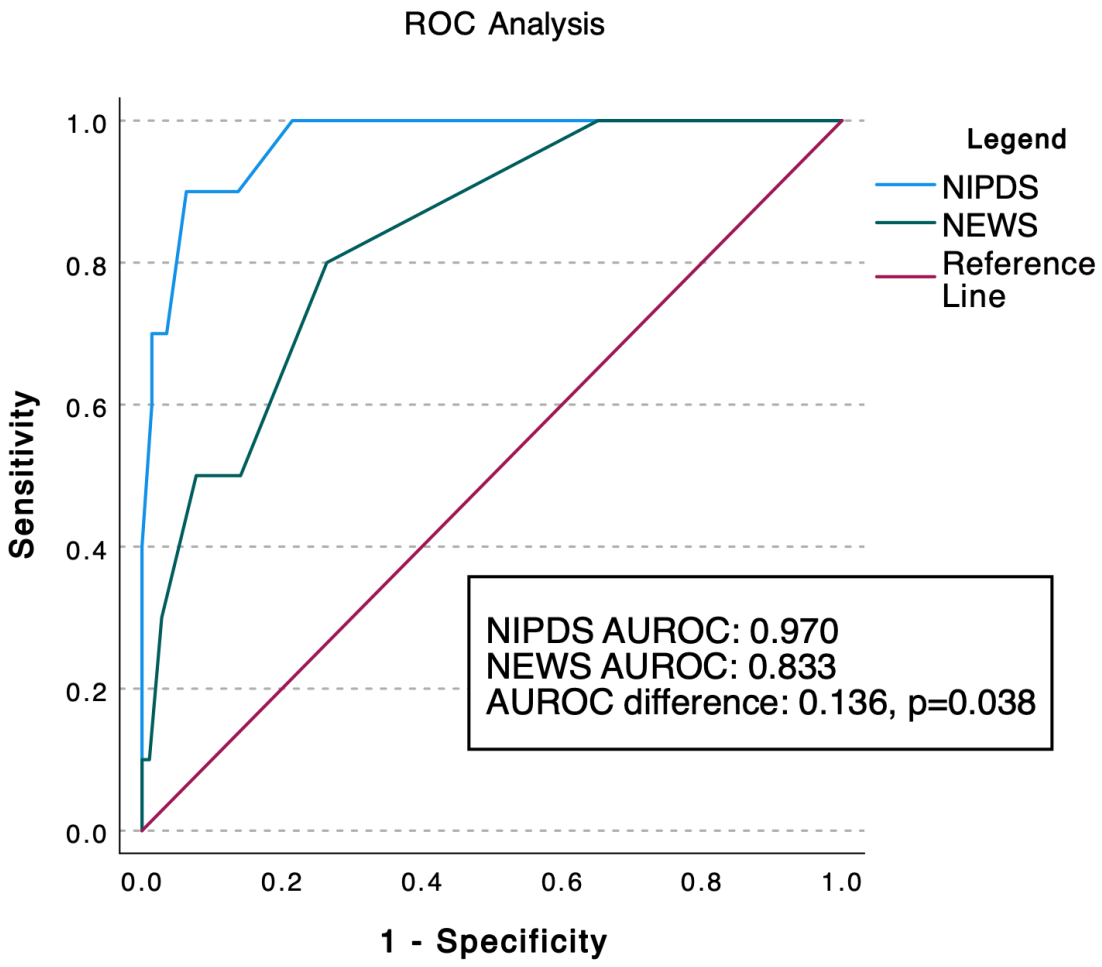
Table 2. Confusion matrices primary and secondary outcomes

The sensitivity and specificity of the NIPDS score to predict the primary outcome were 0.900 and 0.927 respectively (calculated using Table 2). The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of the NIPDS score for the primary outcome were 29.0% and 99.7% respectively. For the secondary outcome, the sensitivity and specificity of the NIPDS score were 0.636 and 0.964 respectively. The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of the NIPDS score for the secondary outcome were 67.7% and 95.7% respectively. For the NEWS score, the sensitivity and specificity to predict the primary outcome were 0.300 and 0.974, respectively. For the secondary outcome, the sensitivity and specificity of the NEWS were 0.212 and 0.986, respectively.

To investigate NIPDS versus NEWS performance, a Receiver Operator Characteristic Curve Analysis was carried out (Figure 2). The NIPDS showed superior performance in predicting the primary outcome (i.e., death OR urgent code call OR unplanned transfer to the ICU) compared with NEWS (AUROC difference 0.136, p=0.038). The NIPDS Gini-index was 0.939,

and a scale threshold of ≥5 was associated with the maximum Kolmogorov–Smirnov metric (Max K-S = 0.837). Youden's index confirmed the optimal threshold for the NIPDS of ≥5 (Youden's index = 0.827).

In univariate analyses, we found no significant effects between the patient's sex or age and the primary outcome (Table 3). If a patient was admitted from the emergency department, there was a reduced risk of reaching the primary outcome (OR 0.05, 95% CI 0.01-0.36). In multiple regression, the NIPDS and NEWS showed an increased risk of reaching the primary outcome within 24 hours after registration (NIPDS OR 1.70, NEWS OR 1.16). The variable indicating if a patient was admitted from the emergency department was excluded since it did not contribute to the model's goodness of fit.



ROC, Receiver Operator Characteristic Curve
AUROC, Area Under The Receiver Operator Curve

Figure 2. Receiver operator curve analysis for the primary outcomes

	Univariate regression analyses				Multiple regression analysis				
		95% CI				95% CI			
	OR	lower	upper	p-value	OR	lower	upper	p-value	R^2 change
Sex: female	2.75	0.70	10.85	0.148	.	.	.	.	.
NIPDS	1.79	1.43	2.23	<0.001	1.70	1.36	2.13	<0.001	.
NEWS	1.67	1.28	2.18	<0.001	1.16	0.83	1.62	0.397	+0.009
Age	1.01	0.97	1.05	0.702	.	.	.	.	.
emergency admission: yes *	0.05	0.01	0.36	0.004	.	.	.	.	.

p-model <0.001; Nagelkerke R-square 0.602
OR, Odds Ratio, NIPDS: Nurse Intuition Patient Deterioration Scale; NEWS: National Early Warning Score
* Emergency admission was not included in the final model since it did not improve the goodness of fit (R-squared)

Table 3. Univariate and multiple binary logistic regression analysis predicting the primary outcome

Decision Curve Analysis was done to estimate the clinical usefulness of using NIPDS, NEWS or a combination of both to predict the primary outcome in this study (Figure 3). We found that across the whole range of treatment threshold probabilities (0-30%), NIPDS performed better regarding Net Benefit compared with NEWS. In settings where the Number Needed To Treat (number of patients to evaluate to detect one patient that could reach the primary outcome) is above 7, a combination of NIPDS and NEWS (NEWS ≥5 OR NIPDS ≥5) can be used to reach

the greatest Net Benefit. In settings where the Number Needed To Treat is below 7, a NIPDS ≥5 provides the greatest Net Benefit.

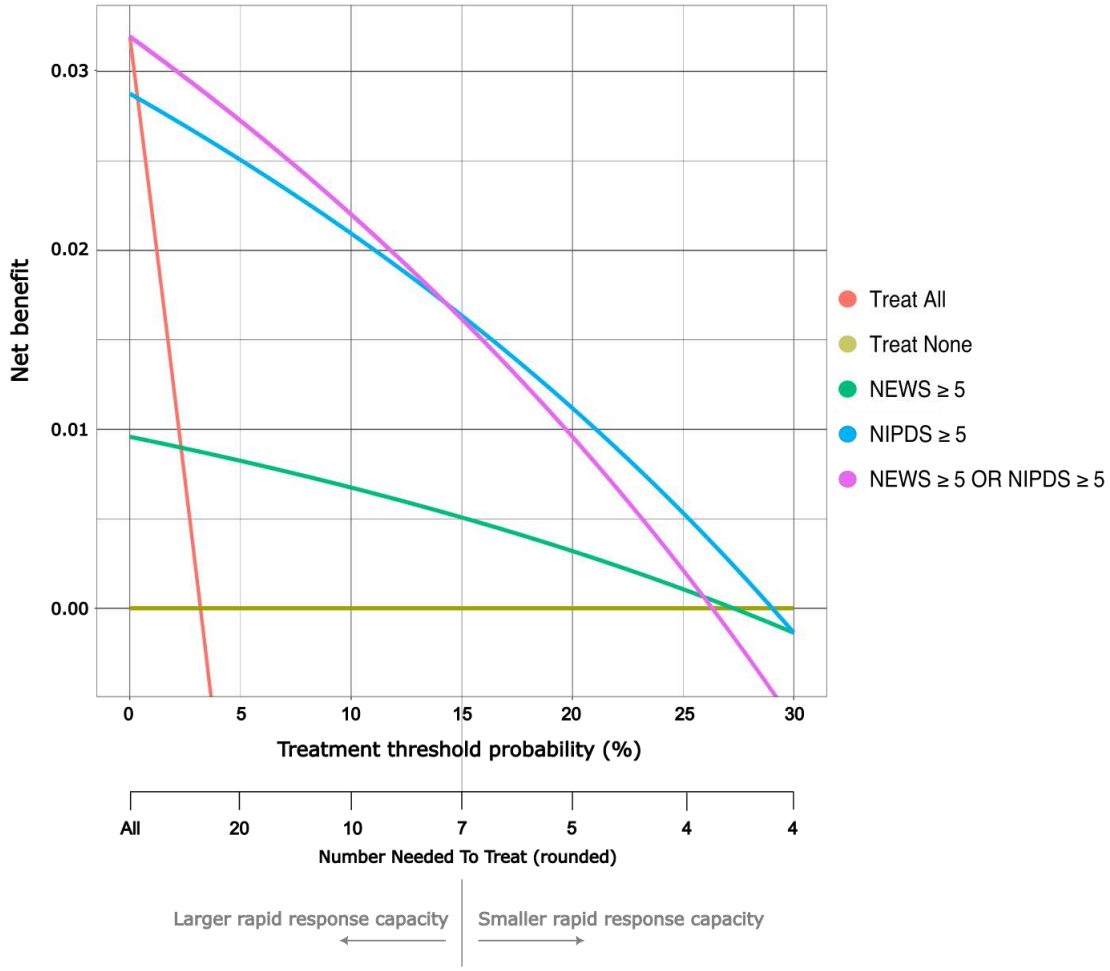


Figure 3. Decision curve analysis indicating overall net benefit per treatment threshold probability

DISCUSSION

In this prospective cohort study, we tested the performance of the Nurse Intuition Patient Deterioration Scale (NIPDS) in addition to the National Early Warning Score (NEWS) to predict serious adverse events in patients admitted to medical, surgical, and geriatric wards of an acute hospital in Belgium. We discovered that the NIPDS showed excellent performance in predicting patients' death, an urgent code call, or an unplanned transfer to the ICU within 24 hours after registration. This confirms our previous results in another setting where we found that nurse intuition is highly predictive for severe outcomes (Haegdorens et al., 2023). A threshold of 5 or higher was in this study confirmed as the optimal threshold to detect patient deterioration.

Compared with the NEWS, an early warning score that is currently being used around the globe, NIPDS performed better and showed more Net Benefit across a range of Threshold Probabilities. Moreover, NIPDS was more accurate in predicting serious adverse events compared with NEWS. It has been shown that one in eight patients who died or were admitted to the ICU had normal vital signs according to vital sign based track-and-trigger scores (Tirkkonen et al., 2020). Therefore, nurse intuition should be used in addition to an aggregated early warning score to minimise the number of missed patients (RCOP, 2017). (Tirkkonen et al., 2020)We believe that a well-developed and validated score measuring nurse worry or intuition such as the NIPDS could support nurses in their quest to detect patient deterioration on medical, surgical, and geriatric wards.

A combination of NEWS with NIPDS (with thresholds of both scores ≥5), as a trigger criterion for rapid response, seems to provide the largest Net Benefit in hospitals that can process a

larger number of rapid response calls. In this study, we found a rather large number of RRT activations (i.e., 9.3%) compared with international studies (Jones, 2014). However, it is known that RRT call rates can vary considerably and largely depend on the organisation of the RRS in the hospital. Around the clock, fully staffed Rapid Response Teams (RRT) are common in Australia but unfortunately not so in the UK or in the European Union (Shiell et al., 2022). In hospitals where rapid response systems are in place with limited or even sometimes zero dedicated RRT capacity, a continuous and large stream of daily alerts could result in additional nursing tasks for ward nurses (e.g., all patients who trigger must be observed more frequently unless it is overruled by an RRT member or responsible physician) and for the RRT itself (e.g., each trigger could result in a call for help). Eventually these false positive events increase workload and strain for staff nurses as well as the RRT. It is known that a degree of over-triage is inherent to well-established rapid response systems (Tirkkonen et al., 2020). We advocate for implementing Rapid Response Systems as they were initially intended. That is, including a well-organised and effective response when calling criteria for rapid response are met (DeVita et al., 2010). However, we must recognise that, in practice, calling criteria are sometimes individually adapted to reduce the number of false positives, aiming to reduce unnecessary nursing tasks that result into increased workload and strain (Olsen et al., 2019). Nurses already use their own clinical judgement as a criterion to initiate a call regardless of the EWS criteria (Stewart et al., 2014). We believe that in settings where the number of patients that can be evaluated and treated by the RRT is lower (Number Needed To Treat <7), the NIPDS could be used as a single calling criterion as this reflects current practice and provides the largest Net Benefit in that specific situation. Importantly, this does not mean that nurses should neglect taking vital signs or stop evaluating Early

Warning Scores but rather combine different instruments to substantiate whether or not a rapid response call is needed.

Harnessing the power of nurses' intuition to detect patient deterioration could be of great importance in settings where resources are limited. Because of its simplicity, the NIPDS could be useful in, for example, standardised protocols specially designed for resource-restricted countries or even during wartime (Taj et al., 2022). Lastly, we are convinced that to successfully implement an RRS, nurses and physicians should receive adequate training with focus on clinical observation, using and interpreting tools such as the NIPDS or NEWS, communication, and rapid response criteria.

LIMITATIONS

The NIPDS was developed in Belgium in a previous study and our first results were confirmed in this second prospective study in a different centre in medical, surgical, and geriatric patients. Since operating characteristics could vary in other or more specialised wards, the NIPDS should be tested accordingly in different patient groups (van Mourik et al., 2023). A significant limitation is that NIPDS was not tested in an international cohort of nurses and patients and has therefore limited external validity. Another limitation is that we used convenience sampling to include patients and therefore did not include all admitted patients on participating wards. Moreover, for practical reasons we only registered serious adverse events in the 24-hour timeframe after admission. This could influence our results since we potentially missed patients not included in this study and serious adverse events occurring after 24 hours length of stay. In addition to the NIPDS registration at admission, nurses could record a NIPDS if they sensed something clinically suspicious. This could be the wrong approach since the aim of scores such as the NIPDS is to provide a 'safety net' for the patient

for timely detection of clinical deterioration (Haegdorens, 2024). In further research, the NIPDS should be tested in another setting where it is being used more frequently during the patient's admission alongside NEWS.

Finally, we acknowledge that using nurse intuition to alert medical doctors on deteriorating patients could be challenging in settings where traditional hierarchical power relations between medical doctors and nurses are still strong (Chua et al., 2020). The exodus of experienced nursing staff during and after the COVID-19 pandemic could potentially exacerbate this issue, as physicians might be sceptical regarding the efficacy of the intuition of less experienced nurses (Xyrichis and Rose, 2024). Nevertheless, a validated score, such as the NIPDS, should be given preference in addition to an Early Warning Score because it translates a subjective feeling to a specific score, and assists less-experienced nurses in identifying clinical cues in their patients.

CONCLUSION

This study underlines the potential of nurse intuition as a valuable tool for early detection of patient deterioration and emphasizes the importance of integrating it into existing rapid response systems. Although the PPV of the NIPDS alone is limited, the NPV is large meaning that nurse intuition adds value in ruling out the possibility of clinical deterioration in the first 24 hours after measurement. A combination of NEWS and NIPDS yielded the highest Net Benefit in settings with ample rapid response capacity. In hospitals with limited rapid response resources, the NIPDS could serve as the calling criterion, recognizing the critical role of nurses' clinical judgment in addition to early warning scores.

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