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Research Article

The predictive value of the modified early warning score for admission to the intensive care unit in patients with a hematologic malignancy – A multicenter observational study

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ABSTRACT

Objectives: The modified early warning score (MEWS) is used to detect clinical deterioration of hospitalized patients. We aimed to investigate the predictive value of MEWS and derived quick Sequential Organ Failure Assessment (qSOFA) scores for intensive care unit admission in patients with a hematologic malignancy admitted to the ward.
Design: Retrospective, observational study in two Dutch university hospitals.
Setting: Data from adult patients with a hematologic malignancy, admitted to the ward over a 2-year period, were extracted from electronic patient files.
Main outcome measures: Intensive care admission.
Results: We included 395 patients with 736 hospital admissions; 2% (n = 15) of admissions resulted in admission to the intensive care unit. A higher MEWS (OR 1.5; 95 %CI 1.3–1.80) and qSOFA (OR 4.4; 95 %CI 2.1–9.3) were associated with admission. Using restricted cubic splines, a rise in the probability of admission for a MEWS $\geq$ 6 was observed. The AUC of MEWS for predicting admission was 0.830, the AUC of qSOFA was 0.752. MEWS was indicative for intensive care unit admission two days before admission.
Conclusions: MEWS was a sensitive predictor of ICU admission in patients with a hematologic malignancy, superior to qSOFA. Future studies should confirm cut-off values and identify potential additional characteristics, to further enhance identification of critically ill hemato-oncology patients.
Implications for Clinical Practice: The Modified Early Warning Score (MEWS) can be used as a tool for healthcare providers to monitor clinical deterioration and predict the need for intensive care unit admission in patients with a hematologic malignancy. Yet, consistent application and potential reevaluation of current thresholds is crucial. This will enable bedside nurses to more effectively identify patients needing adjunctive care, facilitating timely interventions and improved outcome.

Introduction

Patients with a hematologic malignancy, e.g. acute myeloid leukemia and non-Hodgkin lymphoma, are vulnerable for infections and other complications related to their disease and intensive treatment regimens they undergo, including cytotoxic chemotherapy and stem cell transplantations. As a consequence, patients are at increased risk of clinical deterioration during hospital admission (Yeo et al., 2012). Causes of deterioration include infection, sepsis, bleeding, tumor lysis, respiratory insufficiency, leukostasis, and organ-specific toxicities, regularly leading to the need for intensive care unit (ICU) admission (Franchini et al., 2013, Guven et al., 2006, Howard et al., 2011, Porcu

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et al., 2000). Timely recognition of patients with a hematologic malignancy in need of ICU admission is important as previous studies demonstrated that early recognition was associated with a better outcome, and early ICU admission with increased survival (Azoulay et al., 2013, Lengliné et al., 2012, Mokart et al., 2013, Song et al., 2012). One study demonstrated that delayed identification of acute respiratory failure and initiation of respiratory support in immunocompromised patients (including hemato-oncology patients) was associated with increased mortality and intubation rates (Azoulay et al., 2017)). Once admitted to the ICU, mortality rates for this patient group are high, with a 1-year mortality rate of 62% (de Vries et al., 2019).

To timely recognize patients at risk for clinical deterioration and reduce associated adverse outcomes, hospitals worldwide have implemented rapid response teams (Jones et al., 2011). In The Netherlands it is mandatory to have a rapid response system in place (FMS, 2022). A rapid response team is a multidisciplinary group of healthcare professionals who quickly respond to prevent or manage critical patient conditions outside of the intensive care unit (ICU) to improve patient outcomes. Therefore, the majority of rapid response teams operate under the supervision of the ICU. Previous studies in medical and surgical patients demonstrated that the use of rapid response teams was associated with lower mortality and cardiopulmonary arrest rates (Solomon et al., 2016). However, to deploy rapid response teams on the ward, clinical deterioration has to be recognized in a timely manner. Early identification of deteriorating patients and subsequent timely intervention has proven to be difficult (Treacy and Caroline Stayt, 2019). This may partly be explained by the subtle and often complex nature of initial symptoms. As hemato-oncology patients commonly exhibit more severe illnesses compared to patients in conventional hospital wards, this may particularly be relevant for this population.

Multiple scoring systems have been developed to facilitate timely recognition of the potential deteriorating patient (Downey et al., 2017). One of these scoring systems is the Modified Early Warning Score (MEWS). It is an easily applicable, widely used, physiologic score based on a limited number of clinical parameters and recommended by the Dutch Federation of Medical Specialists (see Table 1) (FMS, 2022, Subbe et al., 2001).

MEWS has been validated in several patient populations, with conflicting reports about its potential to predict outcomes. A study highlighted MEWS's limited effectiveness for discerning at-risk oncology patients, though it proved fairly beneficial for general medical and surgical populations (Cooksley et al., 2012, Gardner-Thorpe et al., 2006, Smith et al., 2014, Subbe, Kruger, 2001, Tirotta et al., 2017, Young et al., 2014). Due to scarce evidence available, it is unclear what the predictive value of MEWS is in the relatively vulnerable hemato-oncologic patient population and whether it is the right instrument to detect clinical deterioration in this population (Constantinescu et al., 2021, Lee et al., 2020).

We aimed to investigate the predictive value of MEWS for ICU admission in patients with hematologic malignancies admitted to the ward, by retrospective collection of electronic health data of these patients in two large university hospitals in The Netherlands.

Methods

Study design

We performed a multicenter, retrospective, observational cohort study. For this observational study, the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies were followed (von Elm et al., 2007). Data were collected in two university hospitals in The Netherlands (Radboud University Medical Center, Nijmegen and Amsterdam University Medical Centers, location Academic Medical Center) between January 1, 2018 and January 1, 2020. Both hospitals were part of the HEMA-ICU study group in The Netherlands and used the same electronic patient files sytem (Epic by Epic Systems), allowing for a homogeneous data extraction. All adult patients aged 18 years or older with a previous or active diagnosis of a hematologic malignancy (defined by the 10th edition of the International Statistical Classification of Diseases and Related Health Problems (ICD-10)), admitted to the hematology ward for at least 24 h, of whom at least one MEWS was collected during admission, were considered eligible for inclusion and included in the query.

In both participating centers, per protocol total MEWS was scored at least once daily by the treating nurse. An overview of the MEWS is shown in Table 1. A MEWS is assigned by rating vital signs and concern about the patient from 0 to 3. The vital signs include respiratory rate, oxygen saturation, heart rate, systolic blood pressure, urine output, temperature, and consciousness level. For example, a systolic blood pressure of 71–80 mmHg or above 200 mmHg earns a score of 2. A total MEWS equal to, or higher than, 3 was considered alerting, and reason for consulting the treating physician. If intervention by the physician did not suffice, the rapid response team had to be consulted.

Data collection

Data on age, sex, hematologic diagnosis, hospital length of stay, ICU admission, in-hospital mortality, and daily MEWS scores, including subdomain score if available, were automatically extracted from electronic health records (Epic by Epic Systems), using pre-defined queries developed with and run by the electronic patient file research departments in both centers. These data were collected in encrypted datasets and merged as appropriate. The highest MEWS per admission and the largest increase in MEWS within 24 h per admission were calculated and used for our analyses. Furthermore, we determined the MEWS 3 days prior to the primary outcomes, i.e. ICU admission, discharge, or death. Based on available parameters collected to determine the MEWS, the quick Sequential Organ Failure Assessment (qSOFA) score was also derived from the electronic health records, as this is a commonly used tool to detect clinical deterioration on the ward

Table 1
Modified Early Warning Score.

Score	3	2	1	0	1	2	3
Respiratory rate – breaths/min		<9		9–14	15–20	21–29	30
Saturation with therapy – %	<90						
Heart rate – beats/min		<40	40–50	51–100	101–110	111–129	≥130
Systolic blood pressure – mmHg	70	71–80	81–100	101–200		>200	
Urine production	<75 mL in the last 4 h: 1 point						
Temperature – °C		<35.1	35.1–36.5	36.6–37.5	>37.5		
Consciousness				A	V	P	U
Worried about patient: 1 point							

A modified early warning score (MEWS) is assigned by rating vital signs and concern about the patient from 0 to 3. For example, a systolic blood pressure of 71–80 mmHg or above 200 mmHg earns a score of 2. The ratings of all scores are combined, yielding a total MEWS. Level of consciousness is measured by the AVPU score. A denotes 'Alert': the patient is fully awake; V, 'Verbal': responds to verbal stimulation; P, 'Pain': responds to painful stimulation, and U, 'Unresponsive': completely unresponsive.

(Singer et al., 2016).

Statistical analysis

Data distribution was analyzed for parametric distribution by Shapiro-Wilk tests and histogram plots. Continuous non-parametric variables were expressed as medians and interquartile ranges. Categorical variables were expressed as numbers and percentages, n (%). Difference testing between groups was performed using Mann-Whitney U tests, chi-square tests, or Fisher's exact tests as appropriate. No imputation was used to estimate missing data. No sample size calculation was performed, as all available data from the electronic patient files were retrospectively extracted. All MEWS values used for our analyses were collected on the ward. The predictive value for ICU admission was calculated using the highest MEWS during ward admission and the largest increase in MEWS within 24 h during ward admission. Next, we assessed whether the MEWS measured 3 days prior to ICU admission was predictive for ICU admission, compared to the MEWS 3 days prior to discharge or death. To assess the relationship between the highest MEWS during admission and ICU admission, for visualization and to find clinically relevant cut-off values, a restricted cubic spline model, with knots placed on the 5th, 22.5th, 50th, 77.5th, and 95th percentile of MEWS, was built to plot the probability of ICU admission against the corresponding MEWS (Gauthier et al., 2020). Moreover, we performed logistic regression analyses, computed the area under the receiver operating characteristic curves (AUROC), and calculated sensitivity and specificity for different MEWS cut-off points. Similar analyses were performed for death during hospital admission as outcome and qSOFA score as a predictor. As a sensitivity analysis and to increase statistical power (as combining multiple outcomes results in an increase in the number of events), we used death and/or ICU admission as composite outcome. Similar analyses were performed for MEWS and qSOFA as predictors. We considered statistical significance to be at p 0.05. Analyses were performed using R in R studio, version 4.0.3 (Team, 2020).

Ethical considerations

The Institutional Review Board of Amsterdam UMC determined that the current study did not fall within the scope of the Dutch Medical Research Involving Subjects Act (reference: W20_047 # 20.075) and waived the need for informed consent. However, in accordance with the General Data Protection Regulation, data of patients who explicitly denied permission to use their data for research purposes, were excluded.

Results

Patient characteristics

Data from 746 patients with 9651 admissions at the hematology department were extracted from the electronic patient files. After excluding patients of whom a total MEWS was not registered, a total of 395 patients with 736 admissions due to a hematologic malignancy were included. Fifteen (2%) of these admissions on the ward resulted in ICU admission and 15 resulted in death during hospital admission. Of the 15 admissions to the ICU, 3 patients (20%) died. Twelve patients died on the ward without ICU admission. One patient was admitted to the ICU during two separate hospital admissions.

Table 2 provides an overview of the characteristics of the entire study cohort; of patients that were admitted to the ICU during their hospital stay, and of patients that were not admitted to the ICU. Modified early warning scores were available for 82.7% of the admission days. The highest MEWS values during ward admission (median: 8.0, Interquartile Range (IQR): [6.0–11.0] vs. 3.0 [2.0–5.0], $p < 0.001$) were higher and hospital lengths of stay were longer (28 [18–44] vs. 9 [5–22] days, $p < 0.001$) in patients that were admitted to the ICU compared to patients without ICU admission. Patients needing ICU admission had a larger increase in MEWS within 24 h compared to patients that were not admitted to the ICU (3.5 [3.0–5.0] vs. 2.0 [1.0–3.0], $p < 0.001$). The highest qSOFA scores were more often ≥ 2 in patients admitted to the ICU (before ICU admission), compared to patients remaining on the ward (50.0% vs. 7.6%, $p < 0.001$). We did not find a statistically significant difference in the highest MEWS during ward admission between patients that died during their hospital stay compared to patients that survived their hospital stay (4.0 [2.0–5.5] vs. 3.0 [2.0–5.0], $p = 0.347$). Hospital lengths of stay were significantly longer in non-survivors versus survivors (28 [10–48] vs. 9 [4–22] days, $p = 0.011$). No statistically significant difference between survivors and non-survivors was found for the largest increase in MEWS within 24 h and the highest qSOFA score during ward admission.

Table 2
Admission characteristics for all patients and stratified by ICU admission status.

	All patients *N = 736*	Not admitted to the ICU *N = 721*	Admitted to the ICU *N = 15*	P-value
Center, *n (%)*				0.55
Amsterdam UMC	189 (25.7%)	184 (25.5%)	5 (33.3%)	
Radboud UMC	547 (74.3%)	537 (74.5%)	10 (66.7%)	
Age, years	59 [47–65]	59 [47–66]	57 [41–65]	0.40
Male, n (%)	458 (62.2%)	451 (62.6%)	7 (46.7%)	0.32
Diagnosis, n (%)				0.96
Acute lymphoblastic leukemia	90 (12.2%)	87 (12.1%)	3 (20.0%)	
Acute myeloid leukemia	142 (19.3%)	138 (19.1%)	4 (26.7%)	
Chronic lymphocytic leukemia	28 (3.80%)	28 (3.88%)	0 (0.00%)	
Chronic myeloid leukemia	31 (4.21%)	31 (4.30%)	0 (0.00%)	
Hodgkin's lymphoma	37 (5.03%)	37 (5.13%)	0 (0.00%)	
Multiple Myeloma	128 (17.4%)	126 (17.5%)	2 (13.3%)	
Non-Hodgkin's Lymphoma	255 (34.6%)	249 (34.5%)	6 (40.0%)	
Other	25 (3.40%)	25 (3.47%)	0 (0.00%)	
Died during hospital admission, n (%)	15 (2.04%)	12 (1.66%)	3 (20.0%)	0.003
Hospital length of stay, days	9.4 [4.6–22.5]	8.7 [4.5–20.7]	27.6 [18.0–44.3]	<0.001
Maximum MEWS during admission	3.0 [2.0–5.0]	3.0 [2.0–5.0]	8.0 [6.0–11.0]	<0.001
Largest MEWS increase in 24 h	2.0 [1.0–3.0]	2.0 [1.0–3.0]	3.5 [3.0–5.0]	0.001
Maximum qSOFA during admission				<0.001
0	305 (42.2%)	303 (42.8%)	2 (14.3%)	
1	356 (49.3%)	351 (49.6%)	5 (35.7%)	
2	58 (8.03%)	51 (7.20%)	7 (50.0%)	
3	3 (0.42%)	3 (0.42%)	0 (0.00%)	

Percentages are based on the total number of observations per variable. Medians are reported with interquartile ranges. P-values are based on patients admitted to the ICU versus not admitted to the ICU. UMC denotes University Medical Center; ICU, Intensive Care Unit; MEWS, Modified Early Warning Score; qSOFA, quick Sequential Organ Failure Assessment.

Predictors of outcome

We found that the highest MEWS during ward admission was a predictor of ICU admission with a crude odds ratio (OR) of 1.5 (95% CI: 1.3–1.8), whereas it was not a predictor of death during hospital admission (OR 1.0 (95% CI: 0.8–1.2)). Similarly, the largest increase in

MEWS within 24 h was a predictor of ICU admission (OR 1.4 (95% CI: 1.1–1.8)), whereas it was not a predictor of death during hospital admission (OR 0.9 (95% CI: 0.5–1.5)). Moreover, the highest qSOFA during ward admission was a predictor of ICU admission (OR 4.4 (95% CI: 2.1–9.3), but not of death during hospital admission (OR 0.8 (95% CI: 0.3–1.9).

To visually assess the relationship between the highest MEWS during ward admission on any specific day and the probability of ICU admission, we built a restricted cubic splines model, as displayed in Fig. 1. A higher MEWS during admission was associated with a higher probability of ICU admission, with an evident rise in the probability of ICU admission for MEWS values higher than 6. Compared to patients with a MEWS < 6, patients with a MEWS ≥ 6 had an OR of 22.6 (95% CI: 5.1–101.2) for ICU admission and an OR of 1.2 (95% CI: 0.4–3.7) for death during admission.

Fig. 2 displays the area under the receiver operating characteristics (AUROC) curves for ICU admission and in-hospital mortality based on the highest MEWS and qSOFA scores during ward admission and the largest MEWS increase within 24 h. For MEWS the area under the curves (AUCs) were 0.830 for ICU admission and 0.570 for death during hospital admission, while for qSOFA the AUCs were 0.752 and 0.528, respectively. The AUCs of the largest increase in MEWS within 24 h was 0.801 for ICU admission and 0.548 for death during hospital admission.

For a MEWS ≥ 3, sensitivity was 87% with a specificity of 41% for ICU admission, sensitivity was 67% for death during hospital admission with a specificity of 41%. For a MEWS ≥ 6, sensitivity was 87% with a specificity of 78% for ICU admission, sensitivity was 27% for death during hospital admission with a specificity of 76%. For an increase in MEWS within 24 h by 1, sensitivity was 100% with a specificity of 20% for ICU admission, sensitivity was 80% with a specificity of 19% for death during hospital admission. For an increase in MEWS within 24 h by 3, sensitivity was 80% with a specificity of 67% for ICU admission, sensitivity was 40% with a specificity of 66% for death during hospital admission.

A qSOFA score ≥ 2 had a sensitivity of 50% and specificity of 92% for ICU admission. Due to a low number of events (all patients that died had a qSOFA < 2), sensitivity and specificity were not determined for death during hospital admission.

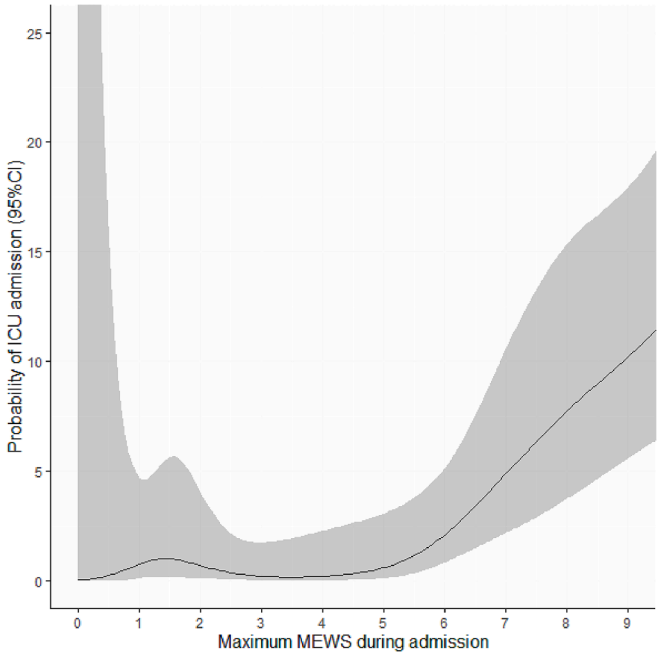

Fig. 1. The relationship between probability of ICU admission and MEWS. Restricted cubic splines model. Confidence interval (95%) is displayed in grey. Probability of ICU admission (%) is displayed on the y-axis. Maximum MEWS during admission on the ward is displayed on the x-axis. Due to the low number of events for patients with a low MEWS, a wide confidence interval is observed.

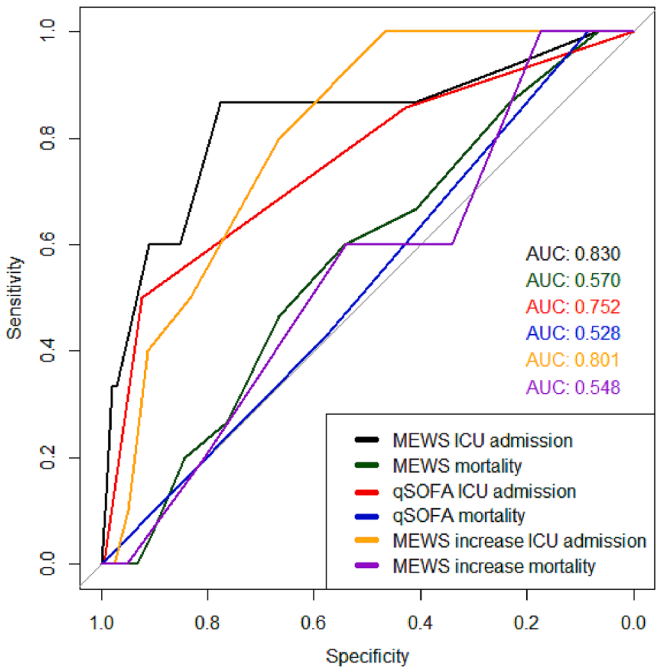

Fig. 2. Area under the receiver operating characteristics (AUROC) curve for ICU admission or mortality based on MEWS and qSOFA score. Sensitivity on y-axis. Specificity on x-axis. Area under the curve is noted inside of the curve. Corresponding colours and predictors are noted in the bottom right corner of the figure.

Fig. 3 visualizes the daily MEWS before ICU admission or discharge. Higher daily MEWS were observed during admissions resulting in ICU admission vs. admissions resulting in discharge or death. Fig. 4 visualizes the AUROC curves for ICU admission based on MEWS the last 3 days before ICU admission. The AUC increased from 0.720 to 0.927 in the final 3 days before ICU admission, with the highest AUC for the last MEWS score (0.927) and the lowest AUC 3 days prior to outcome (0.720).

Highest MEWS, highest qSOFA and the largest increase in MEWS within 24 h were relatively poor predictors of the composite outcome death and/or ICU admission (AUC 0.705; AUC 0.625; AUC 0.520, respectively). See the Appendix for the logistic regression analyses, AUCs, sensitivities and specificities for death during admission and/or ICU admission.

Discussion

We found that both higher MEWS and qSOFA values were predictors of ICU admission in patients with hematological malignancies, but not of death during hospital admission. The currently implemented threshold of MEWS ≥ 3 is a sensitive marker for ICU admission, but lacks specificity in this particular population. After visually assessing the relationship between MEWS and the probability of ICU admission, we increased the threshold to MEWS ≥ 6. This increased the specificity for ICU admission while preserving sensitivity. Moreover, we found that an increase in MEWS within 24 h was predictive of ICU admission, which could be used in future protocols focused on the recognition of deteriorating patients at risk for ICU admission.

Previous studies investigating the predictive value of MEWS for outcome in hemato-oncology patients were conducted in single-center settings with fewer participants compared to our study (Constantinescu et al., 2021, Lee et al., 2020). Our study contributes to this existing body of evidence. We found that it may be appropriate to set the

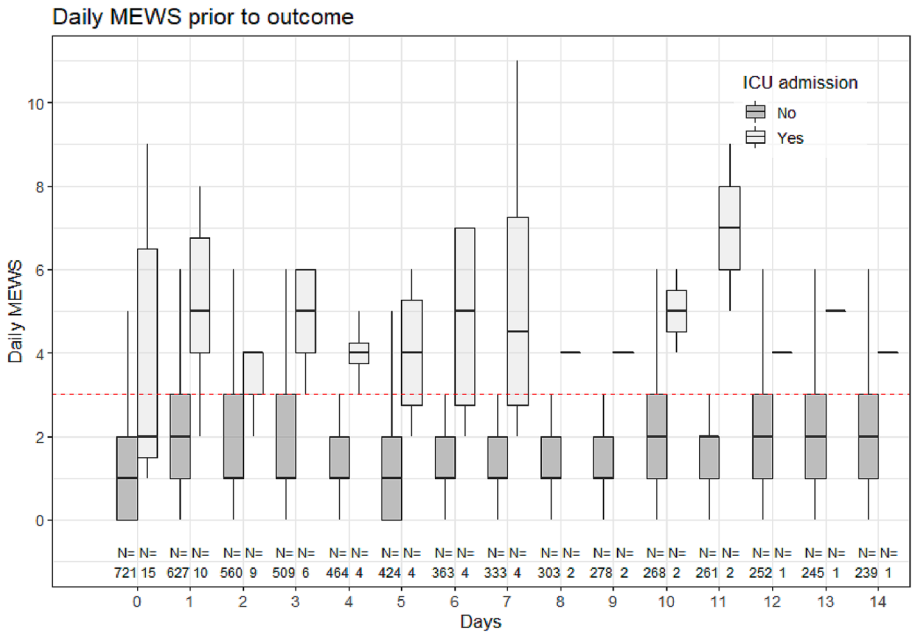

Fig. 3. Daily MEWS until ICU admission, discharge or death. Boxplots for MEWS per day on the ward for non-ICU admissions (dark grey) and ICU admissions (light grey). Days are displayed on the x-axis and are relative to the first MEWS measured (i.e. day 0). Outcome is defined as ICU admission, hospital discharge or death. Numbers at risk are presented below the boxplots.

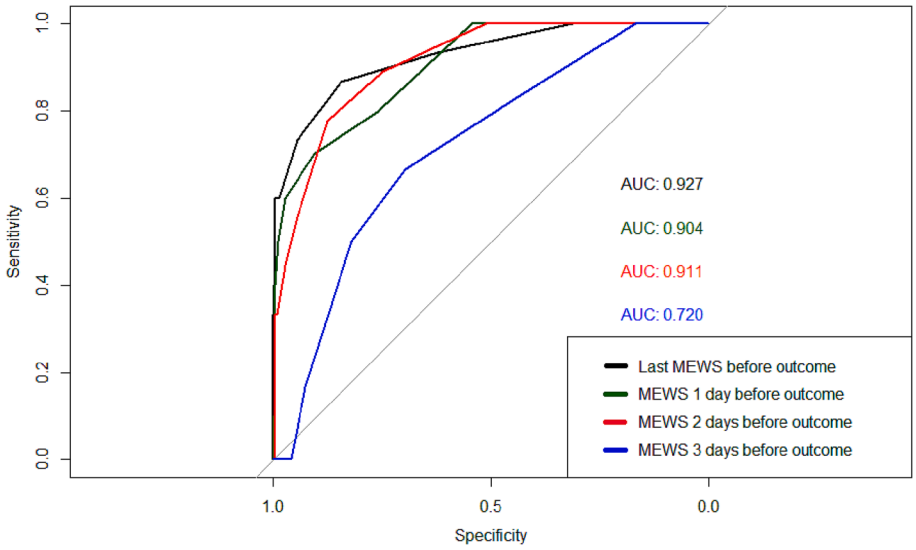

Fig. 4. Area under the receiver operating characteristics (AUROC) curve for ICU admission based on MEWS the days before ICU admission. Sensitivity is displayed on the y-axis. Specificity is displayed on the x-axis. Area under the curve is noted inside of the curve. Corresponding colours and predictors are noted in the bottom right corner of the figure. Outcome is based on ICU admission vs. discharge or death.

threshold for intervention higher in hemato-oncology patients compared to other patients on medical wards. This is in line with a previously performed single-center study (Constantinescu et al., 2021). Additionally, we found that an increase in MEWS within 24 h was predictive of ICU admission. This emphasizes the significance of nurses adhering to daily MEWS reporting protocols. These results can be used for future protocols. In contrast to previously performed studies in the hemato-oncology patient population, we found that MEWS and qSOFA scores were not predictive of death during admission (Constantinescu et al., 2021, Lee et al., 2020). This discrepancy could be explained by the fact that a significant number of patients may have died at home or in a hospice (Howell et al., 2017). Also, patients receiving end of life care may not have their vital signs routinely measured.

Previous studies demonstrated that delayed ICU admission was associated with adverse outcomes (Mokart et al., 2013). Notably, our results demonstrated that MEWS was already indicative of ICU admission up to 2 days prior to the event occurred. This suggests that it may have been possible for a number of patients to be admitted to the ICU earlier, which could have resulted in a better outcome. However, due to the observational design, it is not possible to draw firm conclusions on this. In contrast to MEWS, we found that a qSOFA of $\geq$2 had a low sensitivity for ICU admission (50%). This makes qSOFA an unsuitable scoring system for bedside detection of hemato-oncologic patients at risk for ICU admission. This is in line with a previous study performed in a general population in the emergency department, in which they found that qSOFA was inferior to SIRS and MEWS for detecting sepsis, a

common cause of ICU admission (van der Woude et al., 2018).

The addition of extra variables to MEWS, e.g. blood lactate levels or SpO_2/FiO_2 ratio, may increase the accuracy of predicting ICU admission (Yoo et al., 2015, Young et al., 2014). Also, previous studies in hospitalized patients suggest that implementation of family-initiated escalation of care might result in earlier detection of deterioration (Gill et al., 2016). Whether adding biochemical or family-initiated escalation of care will improve the predictive value of the MEWS might be the subject of future studies.

Ideally, we are able to identify patients at risk of clinical deterioration, before it manifests. A-priori identifying hemato-oncology patients at risk for ICU admission based on their underlying disease and treatment regimen may be helpful (Ferreyro et al., 2021). A study published in 2020 demonstrated that the patient's microbiota was a predictor of mortality in allogeneic hematopoietic-cell transplantation (Peled et al., 2020). Microbiota profiling combined with clinical pheno- or endotyping might also be effective to identify patients at risk, before clinical deterioration is observed. Future research looking into aforementioned factors and identifiers is warranted to enrich current early warning scores such as the MEWS.

Limitations

Since 2012, Dutch hospitals are required to have rapid response systems in place. These rapid response systems make use of early warning scores to timely recognize critically ill patients (Ludikhuize et al., 2015, VMSzorg, 2008). Also, following nationwide guidelines, there is a low threshold for admitting patients with a hematologic malignancy to the ICU (Kusadasi et al., 2017, van Vliet et al., 2014). Remarkably, we only found an ICU admittance rate of 2%. This is considerably lower than what is described in the literature and an important limitation of our study (Ferreyro et al., 2021). As this study was performed before the first COVID-19 cases appeared in our hospitals, there were no structural capacity problems in our ICUs. One possible explanation for the low ICU admittance rate may be that we extracted data from a relatively heterogeneous patient population, using data from patients with an active as well as a history of a hematologic malignancy. This may have resulted in a relatively low proportion of patients that were severely ill and in need of admission to an intensive care unit, e.g. patients admitted in a short stay setting or admitted for non-cancer-related issues. Also, a number of patients may have had a non-ICU admission policy. Unfortunately, it was not possible to distinguish these subsets in our dataset. The relatively low rate of ICU admissions could also be caused by a possible lack of protocol adherence or missing data, as we only collected data from patients of whom the MEWS were available in the electronic patient files. Indeed, a considerable amount of MEWS measurements were missing from the data extracted from the electronic patient system. Furthermore, we found rather wide confidence intervals for the predictive value of MEWS ≥ 6 for ICU admission (however, statistically significant). This may be explained by the relatively low number of events. Although the retrospective nature of our study precluded a pre-defined sample size calculation, and the lack of this might affect the precision of our findings, we maintained statistical power owing to our large sample size. Importantly, our research successfully established that MEWS is predictive of ICU admission. Another limitation of this study was the retrospective and observational study design. It would have been interesting to look at the rate of rapid response system activation in patients with a certain MEWS cut-off. Unfortunately, the amount of rapid response system activations were not collected in this study.

Conclusions

In this retrospective cohort study, the modified early warning score was a sensitive predictor of ICU admission in hemato-oncology patients and outperformed qSOFA, indicating its potential value in detecting clinical deterioration. Future studies should focus on confirmation of the cut-off values and potential additional characteristics, to further enhance identification of the critically ill patient with a hemato-oncological malignancy.

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N/A.

Data availability statement

Censored data are available upon reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2023.103486.

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