The Value of the Modified Early Warning Score in Family Practice

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Abstract

Context: Voorafgaand aan een levensbedreigende gebeurtenis, kunnen de fysiologische parameters van een patiënt veranderen. Wanneer deze veranderingen in een vroeg stadium geregistreerd worden, kan de patiënt adequate zorg krijgen, waardoor een levensbedreigende gebeurtenis of ernstige ziekte vermeden kan worden. De "*Modified Early Warning Score"* (MEWS) is een score die op een gewogen manier een aantal afwijkende parameters beoordeelt en zo een maat geeft voor de ernst van de toestand van de patiënt. De diagnostische accuraatheid van de MEWS werd reeds vaak onderzocht in een ziekenhuisomgeving, maar nauwelijks in de huisartsenpraktijk.

Onderzoeksvraag: Is de MEWS een goed instrument om achteruitgang en dus de hospitalisatienood en mortaliteit te voorspellen bij patiënten met acute en ernstige klachten in de huisartsenpraktijk? Zijn bepaalde parameters individuele voorspellers van deze achteruitgang?

Methoden: We includeerden opeenvolgende volwassen patiënten die presenteerden met acute of plots verergerende, mogelijks ernstige klachten. De volgende parameters werden geregistreerd: systolische bloeddruk, hartritme, ademhalingsfrequentie, temperatuur, AVPU-score, zuurstofsaturatie, nieuwe neurologische uitval (ja/neen) en capillaire refill. De opvolging was na 1 maand en volgende parameters werden geregistreerd: de initiële werkdiagnose, de finale diagnose, hospitalisatie (ja/neen), mortaliteit (ja/neen) en doodsoorzaak. Bij geschikte registraties werd de MEWS berekend en werd er gekeken naar de correlatie tussen een verhoogde MEWS en de kans op hospitalisatie en mortaliteit. Deze correlatie werd ook onderzocht bij elke individuele parameter.

Resultaten: Er werden 98 registraties geïncludeerd, waarvan er 58 geschikt waren om de MEWS te berekenen. Voor hospitalisatie was bij een MEWS ≥ 1 de sensitiviteit 0.93, maar de specificiteit 0.24. Bij een MEWS ≥ 2 was de sensitiviteit 0.64 en de specificiteit 0.62. De area under the curve (AUC) was 0.66. Voor mortaliteit was bij een MEWS ≥ 1 de sensitiviteit 0.86, maar de specificiteit 0.16. Bij een MEWS ≥ 2 was de sensitiviteit 0.86 en de specificiteit 0.53. De AUC was 0.73. De ademhalingsfrequentie kon weerhouden worden als een individuele predictor voor hospitalisatie (sensitiviteit = 0.87) en mortaliteit (sensitiviteit = 0.86). Nieuwe neurologische uitval had een PPV = 0.80 voor hospitalisatie. Een systolische bloeddruk ≤ 100 mmHg had een PPV = 0.70 voor hospitalisatie. Een afwijkende AVPU-score had een PPV = 0.75 voor hospitalisatie en een PPV = 0.40 voor mortaliteit.

Conclusie: Volgens deze studie is de MEWS geen goede diagnostische test voor de hospitalisatienood of mortaliteit in de huisartsenpraktijk. Een verhoogde ademhalingsfrequentie kon wel weerhouden worden als een goed individuele voorspeller voor hospitalisatie en mortaliteit.

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Abstract

Context: Deterioration in hospitalized patients is often preceded by measurable changes in physiological parameters. By detecting these changes early, the patient can receive appropriate care and critical events or serious illness can be avoided. The *"Modified Early Warning Score"* (MEWS) is a composite score weighted by the severity of derangement of several physiological parameters. It is a measure for the severity of the condition of the patient. The diagnostic accuracy of the MEWS has often been studied in a hospital setting, but seldom in family practice.

Aim: To assess whether the MEWS is an adequate tool to predict deterioration, and thus need for hospitalization, or mortality in patients presenting with acute and severe complaints in family practice. Are certain parameters individual predictors of this deterioration?

Methods: We included consecutive adult patients presenting with acute or suddenly aggravating and possibly severe symptoms. The following parameters were recorded: systolic blood pressure, heart rate, respiratory rate, temperature, AVPU-score, oxygen saturation, new neurological deficit (yes/no) and the capillary refill. After a follow-up period of 1 month we recorded the initial working diagnosis, the final diagnosis, hospitalization (yes/no), mortality and cause of death. In suitable recordings, the MEWS was calculated and the correlation between the MEWS and hospitalization and mortality was investigated. We also investigated this correlation for each individual parameter.

Results: 98 registrations were included, 58 were suitable to calculate the MEWS. For hospitalization, at a MEWS ≥ 1, the sensitivity was 0.93, but the specificity was 0.24. At a MEWS ≥ 2, the sensitivity was 0.64, the specificity was 0.62. The area under the curve (AUC) was 0.66. For mortality, at a MEWS ≥ 1, the sensitivity was 0.86, but the specificity was 0.16. At a MEWS ≥ 2, the sensitivity was 0.86, the specificity was 0.53. The AUC was 0.73. The respiratory rate was an individual predictor for hospitalization (sensitivity = 0.87) and mortality (sensitivity = 0.86). The PPV for new neurological deficit was 0.80 for hospitalization. A systolic blood pressure ≤ 100 mmHg had a PPV of 0.70 for hospitalization. A deviating AVPU-score had a PPV of 0.75 for hospitalization and a PPV of 0.40 for mortality.

Conclusion: This study does not support the diagnostic use of the MEWS in family practice, but the respiratory rate is an independent predictor of deterioration.

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1. Introduction

Deterioration in hospitalized patients is often preceded by measurable changes in physiological parameters. (1) By detecting these changes early, the patient can receive appropriate care and critical events or serious illness can be avoided. (2) It is important that patients who might benefit from more intensive care (e.g. transportation to high dependency unit or intensive care unit) are well selected. Over the years, different early warning scores (EWS) have been developed to help make this selection especially in a hospital setting. (3–5) The modified early warning score (MEWS) is one of these scores. The original MEWS **(table 1)** is a composite score weighted by the severity of derangement of several easy to measure physiological parameters such as systolic blood pressure, heart rate, respiratory rate, temperature and level of consciousness. (5) The score ranges from 0 to 14, the highest score indicates the worst situation.

In hospital wards, the MEWS is now considered standard of care (6), although the studies investigating outreach and early warning scores on hospital wards are diverse and the methodological quality is generally poor. (7,8) Sensitivities (median 0.43) and positive predictive values (median 0.37) are low. (8) Nevertheless, there is sufficient evidence from observational work that early warning score systems facilitate recognition of abnormal physiological parameters in deteriorating patients, alerting ward staff to intervene. (9)

When used as a triage tool in emergency departments (ED), an elevated MEWS can identify medical patients in need of hospital admission or those at increased risk of in-hospital death (10), but the use of early warning scores in the ED has its limitations as well. (11,12)

Few studies investigate the utility of the MEWS or other early warning scores in an out-of-hospital setting. Most of them are conducted in the emergency medical services transport prior to arriving at the ED. (13–18)

The number of studies conducted in family practice are even more limited. (19–21) The aim of this study is to assess whether the MEWS can be an adequate tool to predict deterioration, and thus need for hospitalization, or mortality in patients presenting with acute and possibly severe complaints in family practice.

2. Material and Methods

2.1 Design

This is a prospective cohort study of adult patients presenting with acute and possibly severe complaints in family practice. We assessed the diagnostic accuracy of the original MEWS (and some additional parameters) in the acute setting in family practice. Is there a correlation between an elevated MEWS and hospitalization (>24 hours) or mortality? In addition, an attempt was made to identify parameters that were independent predictors of these endpoints.
The follow-up was organized after at least 30 days.

2.2 Study population

In the period from April 2016 to February 2017, family doctors in the Belgian provinces of Limburg and Vlaams-Brabant were asked to participate in this study.
We included consecutive adult patients (> 18 years of age) presenting with acute or suddenly aggravating and possibly severe symptoms, such as:

- Retrosternal chest pain
- Cardiac arrhythmia
- Shortness of breath
- New neurological deficit
- Impaired consciousness or consciousness disorders (including convulsions, delirium,…)
- Alarming pain (e.g. acute abdomen, alarming headache,…)
- Acute hypotension or shock

2.3 Measurements

When patients met the inclusion criteria (see above), following data were registered using a registration form **(fig. 1)**: initials of the patient, date of the contact, date of birth, sex, systolic blood pressure (mmHg), heart rate (bpm), respiratory rate (breaths/min), temperature (°C) and AVPU-score (alert, responsive to voice, responsive to pain, unresponsive), to calculate the MEWS. Some additional parameters were recorded to test for a possible additional value in family practice setting: oxygen saturation (%), whether or not there was a new neurological deficit (yes/no) and the capillary refill > 2 sec. (yes/no). For each parameter there was the option “not measured”. Both contacts at the doctor’s surgery and at the patient’s home were included. The family doctors were asked not to calculate the MEWS to prevent bias.
The follow-up was organized after at least 30 days and following data were collected: Was it a contact at the doctor’s surgery or a house call? What was the initial working diagnosis? What was the final diagnosis (based on all available information at that time)? Was the patient hospitalized for more than 24 hours (yes/no)? Did the patient die within the follow-up period (yes/no)? If so, what was the date and cause of death?
The original MEWS was calculated if all parameters were recorded or if only temperature was missing. Missing values for temperature were considered to be normal. The main reason of the family doctors for not recording the temperature was the absence of fever in the patient’s history.

2.4 Analysis

SAS and SPSS statistical software were used to perform the analyses.
For each cut-off point of the MEWS the following statistical measures were calculated for diagnostic accuracy: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio and negative likelihood ratio.
A Receiver Operating Characteristic (ROC) curve was constructed to determine the best cutoff value for the MEWS.
To identify parameters that are individual predictors of the end-points, sensitivity, specificity, PPV, NPV, positive likelihood ratio and negative likelihood ratio were also calculated for each individual parameter.
After elaborate discussion in the research group, it was decided that a sensitivity of 0.90 and a specificity of 0.80 were regarded as satisfactory.

2.5 Ethical approval

This study design was approved by the Ethical review board of the "Master in de huisartsen-geneeskunde (Leuven e.a.)" under reference mp11278.

3. Results

3.1 Registrations

In total 100 registrations were made by 15 family doctors working in 7 different practices. Two registrations were excluded: one because the inclusion criteria were not fulfilled, one due to lack of follow-up information.
The registration was complete (or only temperature was missing) in 58 cases (59%). In these cases the MEWS was calculated. An overview of the missing individual parameters is given in **table 2**.

3.2 Patients' characteristics

The patients' characteristics are summarized in **table 3**.
The median age of the patients included was 70 years. There were 58 (59%) men and 40 (41%) women.
Forty-eight patients (49%) were hospitalized for more than 24 hours and 8 patients (8%) died.
For the included registrations, the mean score of the MEWS was 1.9, with a range from 0-7, the mean MEWS for hospitalized patients 2.3, and 3.1 for patients who died.

The most frequently reported inclusion criteria were shortness of breath in 37 cases (38%), retrosternal chest pain in 18 cases (18%), and alarming abdominal pain in 15 cases (15%) **(table 4)**.
The initial working diagnosis was possible acute coronary syndrome in 13 cases (13%), acute exacerbation of chronic obstructive pulmonary disease (COPD) in 12 cases (12%) and pneumonia in 10 cases (10%). In 11 cases (11%) the initial working diagnosis was unclear. The most common final diagnosis was acute exacerbation of COPD in 11 cases (11%), followed by acute coronary syndrome in 10 cases (10%) and pneumonia in 9 cases (9%). In 10 cases (10%) there was no clear final diagnosis. A detailed overview of all initial working diagnoses and final diagnoses is given in **table 5** and **table 6**, respectively.
The cause of death was pneumonia in 3 cases, a malignancy in 2 cases, acute liver failure in 1 case, cerebral hemorrhage in 1 case and endocarditis in 1 case. All patients who died were referred to the ED and hospitalized, except for one because of a pre-existing do not resuscitate (DNR) code. This patient was excluded for all calculations regarding hospitalization and included for all calculations regarding mortality. The MEWS of these patients ranged from 0 to 6, see **table 7**.

3.3 MEWS

Fifty-eight registrations were suitable to calculate the MEWS. The indications of diagnostic accuracy for hospitalization and mortality of the different cut-off points of the MEWS are presented in **table 8** and **table 9**, respectively.
The ROC curve of hospitalization **(fig. 2)** shows an ideal cut-off point between MEWS ≥ 1 and MEWS ≥ 2. At a MEWS ≥ 1, the sensitivity is 0.93, the specificity is 0.24, the PPV is 0.54, the NPV is 0.78, the positive likelihood ratio is 1.22 and the negative likelihood ratio is 0.3. At a MEWS ≥ 2, the sensitivity is 0.64, the specificity is 0.62, the PPV is 0.62, the NPV is 0.64, the positive likelihood ratio is 1.7 and the negative likelihood ratio is 0.58. The area under the curve (AUC) is 0.66 (95% CI: 0.52-0.80).
The ROC curve of mortality **(fig. 3)** shows an ideal cut-off point of MEWS ≥ 2. At this point the sensitivity is 0.86, the specificity is 0.53, the PPV is 0.20, the NPV is 0.96, the positive likelihood ratio is 1.82 and the negative likelihood ratio is 0.27. The AUC is 0.73 (95% CI: 0.50-0.96).

3.4 Independent predictors

In **table 10** and **table 11** all individual parameters are stratified in the categories used in the MEWS. Indicators of diagnostic accuracy were calculated whereby hospitalization **(table 10)** and mortality **(table 11)** were considered as true positive.
Of the parameters within the MEWS (systolic blood pressure, heart rate, respiratory rate, blood pressure and AVPU-score), an increased respiratory rate can be considered an independent predictor for hospitalization and mortality with a sensitivity of 0.87 and 0.86 respectively. There were no other independent predictors within the MEWS. The PPV of a systolic blood pressure ≤ 100 mmHg is 0.70 for hospitalization and 0.27 for mortality. The PPV of a deviating AVPU-score is 0.75 for hospitalization and 0.40 for mortality.
New neurological deficit, oxygen saturation and capillary refill were additionally registered parameters. New neurological deficit has a PPV of 0.80 for hospitalization.

4. Discussion

4.1 Overview of the main study results

There were 98 registrations included in this study. Forty-eight patients (49%) were hospitalized and 8 patients (8%) died. All of the patients who died were hospitalized, except for one because of a pre-existing DNR-code.
Fifty-eight registrations (59%) qualified to calculate the MEWS. The overall mean score of the MEWS was 1.9, with a range from 0-7, the mean MEWS for hospitalized patients 2.3, and 3.1 for patients who died.

The ROC curve of hospitalization **(fig. 2)** shows an ideal cut-off point between MEWS ≥ 1 and MEWS ≥ 2. At a MEWS ≥ 1, the sensitivity (0.93) is high, but the specificity (0.24; 95% CI: 0.11-0.42) is too low to be acceptable in the clinical practice. At a MEWS ≥ 2 the specificity rises to 0.62, but the sensitivity drops to 0.64 (95% CI: 0.46-0.79). Which means that 36% of the patients with a MEWS < 2 still required hospitalization. With these values the MEWS does not reach the preset threshold of sensitivity and specificity agreed upon within the research group. With an AUC for hospitalization of 0.66 (95% CI: 0.52-0.80), the accuracy of the MEWS for hospitalization in this study should be considered as poor. (22)
The ROC curve of mortality **(fig. 3)** shows an ideal cut-off point of MEWS ≥ 2. At this point the sensitivity is 0.86 (95% CI: 0.49-0.97), the specificity is 0.53 (95% CI: 0.40-0.66). Neither the threshold value for sensitivity nor specificity is met, but the current confidence intervals are broad. The AUC for mortality is 0.73 (95% CI: 0.50-0.96). The accuracy of the MEWS for mortality is better than for hospitalization in this study and should be considered as fair. (22)

We assessed whether individual parameters were independent predictors for deterioration, and thus need for hospitalization, or mortality. Systolic blood pressure, heart rate, temperature and AVPU score show a high specificity and low sensitivity for hospitalization and mortality. As the aim was screening for deterioration, high sensitivity was essential. We can conclude that these individual parameters are not useful to help predict the need for hospitalization or predict mortality in family practice.
From the parameters used to calculate the MEWS, a respiratory rate > 14 breaths/minute was the only independent predictor for hospitalization (sensitivity = 0.87) and mortality (sensitivity = 0.86). This is in accordance with the literature. (9,23) Despite this fact, the respiratory rate was only measured in 65% of all registrations, which made it the second least registered parameter. In contrast, the oxygen saturation was registered in 74%, but showed less diagnostic accuracy (sensitivity = 0.17 for hospitalization; sensitivity = 0.29 for mortality). This finding might be explained by the ease of the measurement of the oxygen saturation (and heart rate) using a small portable device, which is not yet the case for the measurement of the respiratory rate. Some doctors might find measuring the respiratory rate circuitous.
A systolic blood pressure ≤ 100 mmHg has a PPV of 0.70 for hospitalization. When the patient was only responsive to voice or pain, or was unresponsive, they were hospitalized in 75% of the cases. More importantly, the mortality rate was 40%. There were too little recordings for a systolic blood pressure ≥ 200 mmHg, a heart rate ≤ 50 bpm and a capillary refill > 2 seconds (an additionally recorded parameter) to draw any firm conclusions.
Four out of the five patients with a new neurological deficit were hospitalized (PPV = 0.80). This parameter could be a valuable addition to the MEWS.

4.2 Literature

A search of the literature regarding the MEWS in family practice uncovered only 4 articles.
Mols et al. suggested to use the MEWS to assess the dyspneic patient in family practice, but they did not investigate the diagnostic accuracy of the score in this setting. (24)
A Danish study concluded that the early warning score is adequate to trace elderly in need of medical assistance in primary care. At a EWS ≤ 2, 6% of the patients were hospitalized. At a EWS ≥ 5 this number increased to 31%. (19)
A study conducted in family practice including patients presenting with shortness of breath or chest pain, found a sensitivity of 0.88 and a specificity of 0.75 for hospitalization at a MEWS ≥ 2. These results almost reach the preset threshold of sensitivity and specificity agreed upon within our research group. The author suggested a MEWS ≥ 3 as a good predictor of hospitalization (sensitivity = 0.76; specificity = 0.92), choosing for a higher specificity. (20)
The aim of the FLU-CATs study was to evaluate the performance of the triage tools CATs and PMEWS in predicting hospital admission and death in patients presenting with influenza like illness to general practitioners during interpandemic winter seasons, but there were too few outcome events from which to draw any conclusions regarding the performance of the triage tools. (21)

More research is done in the prehospital setting. Leung et al. found that the optimal cut-off to identify non-trauma patients requiring lifesaving intervention within 4h of presentation to the ED was MEWS ≥ 3 (sensitivity = 0.57; specificity = 0.76) and the AUC was 0.72 (95% CI: 0.69-0.75). (17) In comparison to clinical judgement alone a MEWS with a cut-point of 4 resulted in a sensitivity of 0.72 (95% CI: 0.63-0.83) and a specificity of 0.85 (95% CI: 0.84-0.86), with an AUC of 0.80 for the occurrence of an adverse event within 24h of admission to the hospital. (15) A systematic review concluded that the ability of early warning scores to accurately predict critical illness in the prehospital setting was uncertain and that the early warning scores did not perform as well as in the hospital setting, despite promising results from a limited number of studies. The overall methodological quality of the included studies was low. (18)

4.3 Strengths and limitations

The recordings of the parameters were taken by the family doctors during their contact with the patients. The realistic approach is a strength of this study. This study is also an addition to the research of the accuracy of the MEWS in family practice. Until now, this research is very limited. By also analyzing the individual parameters, we were able to determine the respiratory rate as an independent predictor for deterioration.
There are several limitations to this study. First the small amount of recordings (98 registrations were included). Second the reasonably high rate of missing values, because of which only 58 registrations could be used to calculate the MEWS. Finally, the inclusion criteria were rather subjective in some cases (e.g. “alarming pain”) and during the registration period there might have been several patients meeting the inclusion criteria, who were not included in this study, so also violating the requirement of consecutive patients.

4.4 Consequences for the clinical practice and future research

An elevated respiratory rate was found to be an independent predictor for hospitalization and mortality, although it was the second least recorded parameter. A higher proportion of the recordings of the respiratory rate might be more likely with the use of a small portable device.

Together with taking the presence of a new neurological deficit into account, these adjustments might improve the diagnostic accuracy of the MEWS in family practice.
A design for future research could be to include all patients during the study period to eliminate inclusion bias and to aim for complete registrations.

5. Conclusion

This study could not confirm the diagnostic accuracy of the MEWS in family practice.
The AUC for hospitalization is 0.66, therefor the accuracy of the MEWS for hospitalization in this study should be considered as poor. The accuracy of the MEWS for mortality (AUC = 0.73) is better than for hospitalization and should be considered as fair.
From the parameters used to calculate the MEWS, an increased respiratory rate is the only independent predictor for hospitalization (sensitivity = 0.87) and mortality (sensitivity = 0.86).
A higher proportion of the recordings of the respiratory rate, more likely with the use of a small portable device, and taking the presence of a new neurological deficit into account in the MEWS might improve its diagnostic accuracy in family practice.

6. Figures

Figure 1: MEWS Registration Form (in Dutch)

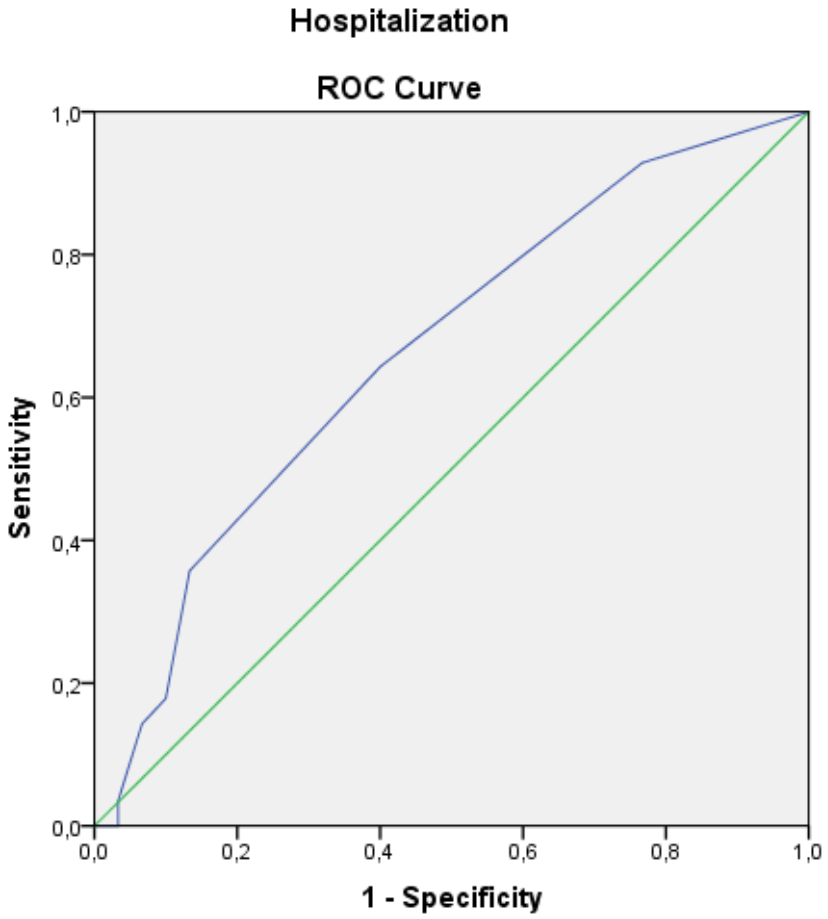
Registratieformulier MEWS

Initialen patiënt: ……. Datum: …/…/…
Geboortedatum: …/…/…
Geslacht: M/V

		Niet gemeten
Systolische Bloeddruk (mmHg)	…	0
Hartslag (slagen/min)	…	0
Zuurstofsaturatie (%)	…	0
Ademhalingsfrequentie (/min)	…	0
Temperatuur (°C)	…	0
AVPU*	…	0
Nieuwe neurologische uitval	0 ja 0 neen	0
Capillaire Refill >2s	0 ja 0 neen	0

*AVPU: **A**: Alert; **V**: reactie enkel op stem (Voice); **P**: reactie enkel op pijn (Pain); **U**: niet reactief (Unresponsive).

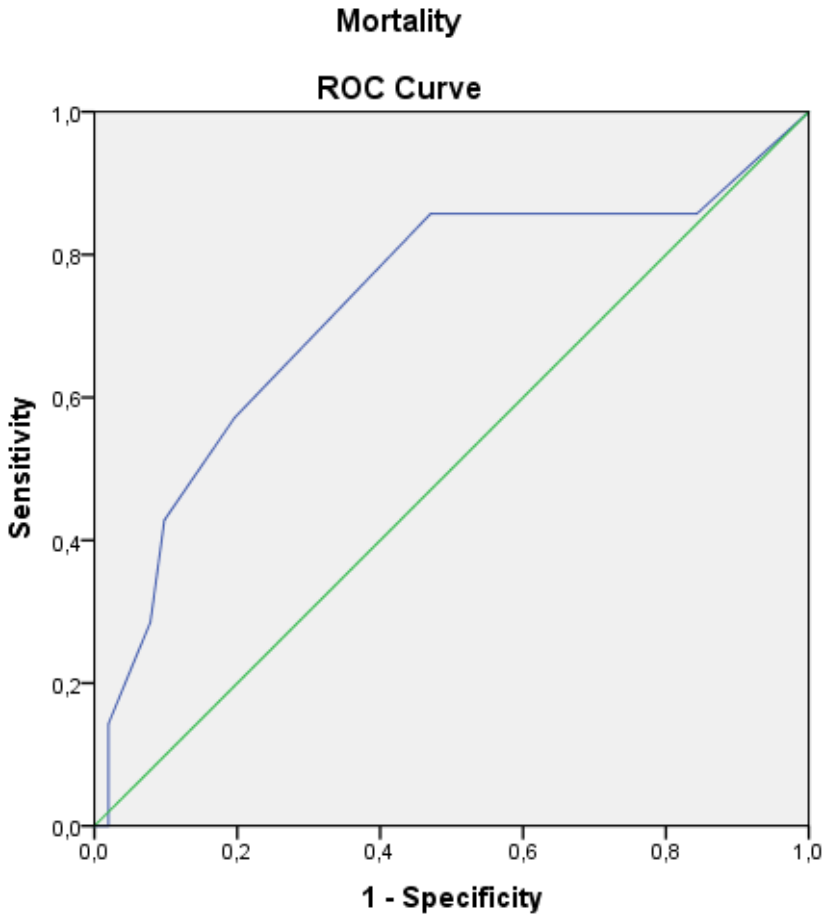
Figure 2: The ROC curve of hospitalization



Diagonal segments are produced by ties.

AUC: 0.66 (95% CI: 0.52-0.80)

Figure 3: The ROC curve of mortality



Diagonal segments are produced by ties.

AUC: 0.73 (95% CI: 0.50-0.96)

7. Tables

Table 1: Modified early warning score (MEWS)*

	3	2	1	0	1	2	3
Systolic blood pressure (mmHg)	≤ 70	71-80	81-100	101-199		≥ 200	
Heart rate (bpm)		< 40	40-50	51-100	101-110	111-129	≥ 130
Respiratory rate (per minute)		< 9		9-14	15-20	21-29	≥ 30
Temperature (°C)		< 35		35-38.4		≥ 38.5	
AVPU score**				Alert	Reacting to Voice	Reacting to Pain	Unresponsive

* Fullerton JN, Price CL, Silvey NE, et al. Is the Modified Early Warning Score (MEWS) superior to clinician judgement in detecting critical illness in the pre-hospital environment? Resuscitation 2012; 83(5):557–562.

** AVPU: A: Alert; V: reactie enkel op stem (Voice); P: reactie enkel op pijn (Pain); U: niet reactief (Unresponsive).

Table 2: Missing values

	Missing (N)	Percentage of total (%)
Systolic blood pressure	2	2
Heart rate	7	7
Respiratory rate	34	35
Temperature	40	41
AVPU	0	0
Neurological deficit	0	0
Oxygen saturation	25	26
Capillary refill	68	69

Table 3: Patients' Characteristics

Variables	Total N=98	Percentage (%)	Median	Range	Mean
Sex					
Men	58	59			
Women	40	41			
Type of contact					
Contact at the doctor's surgery	57	58			
House call	41	42			
Age (years)			70	18-95	65
MEWS all	58	59	2	0-7	1,9
MEWS of patients referred to the ED	54	55	2	0-6	2,2
MEWS of patients hospitalized	48	49	2	0-6	2,3
MEWS of patients who died	8	8	3	0-6	3,1

Table 4: Inclusion criteria

	Total N=98	Percentage (%)
Shortness of breath	37	38
Restrosternal chest pain	18	18
Alarming abdominal pain	15	15
Cardiac arrhythmia	10	10
Impaired consciousness	5	5
New neurological deficit	5	5
Other alarming pain	4	4
Acute hypotension or shock	2	2
Anaphylactic reaction	2	2

Table 5: Initial working diagnosis

	Total N=98	Percentage (%)
Possible acute coronary syndrome	13	13
Acute exacerbation of COPD	12	12
Pneumonia	10	10
Atrial fibrillation	8	8
Stroke/ cerebral hemorrhage	7	7
Acute heart failure	5	5
Acute appendicitis	4	4
Hyperventilation	3	3
Gastritis/ esophagal stricture	3	3
Anaphylactic reaction	2	2
Malignancy	2	2
Musculoskeletal pain	2	2
Shock	2	2
Acute liver failure	1	1
Asthma	1	1
Childbirth	1	1
Flu	1	1
Hypotention	1	1
Infectious arthritis	1	1
Intestinal obstruction	1	1
Pancreatitis	1	1
Pericarditis	1	1
Pneumothorax	1	1
Upper respiratory tract infection	1	1
Urolithiasis	1	1
Vasovagal response	1	1
Gastroenteritis	1	1
Unclear	11	11

Table 6: Final diagnosis*

	Total N=98	Percentage (%)
Acute exacerbation of COPD	11	11
Acute coronary syndrome	10	10
Pneumonia	9	9
Atrial fibrillation	8	8
Cancer	4	4
Hyperventilation	4	4
Stroke	3	3
Acute appendicitis	3	3
Acute heart failure	3	3
Allergic reaction	2	2
Atrial flutter	2	2
Endocarditis/pericarditis	2	2
Gastritis/ Peptic ulcer disease	2	2
Gastroenteritis	2	2
Musculoskeletal pain	2	2
Acute cholecystitis	1	1
Acute liver failure	1	1
Acute pancreatitis	1	1
Asthma	1	1
Benigne paroxysmal positional vertigo	1	1
Bradyarrhythmia	1	1
Cardiogenic shock	1	1
Childbirth	1	1
Flu	1	1
Functional abdominal pain syndrome	1	1
Gluteal abcess	1	1
Hypotension	1	1
Intestinal obstruction	1	1
Intravascular catheter-related infection	1	1
Obstipation	1	1
Pleural effusion	1	1
Pneumothorax	1	1
Substance abuse	1	1
Upper respiratory tract infection	1	1
Urolithiasis	1	1
Vasovagal response	1	1
Unclear	10	10

*1 month after the initial contact.

Table 7: Deceased

Cause of death	Total N=8	MEWS	Reason for initial contact and/ or initial working diagnosis
Pneumonia	3	2	atrial fibrillation
		3	Pneumonia
		4	Pneumonia
Malignancy	2	2	thoracic pain (diagnosis: progressive lungcancer)
		6	intravascular catheter-related infection (history of esophagal cancer)
Acute liver failure	1	5	acute liver failure
Cerebral hemorrhage	1	0	Stroke
Endocarditis	1	0	endocarditis (cause of death: septic shock)

Table 8: Diagnostic accuracy for hospitalization

MEWS	N	%	N hospitalization	Sensitivity	95% CI	Specificity	95% CI	PPV	95% CI	NPV	95% CI	LR+	95% CI	LR-	95% CI
≥1	48	84	26	0,93	0,77-0,98	0,24	0,11-0,42	0,54	0,40-0,67	0,78	0,45-0,94	1,22	0,97-1,54	0,30	0,07-1,30
≥2	29	51	18	0,64	0,460-0,79	0,62	0,44-0,77	0,62	0,44-0,77	0,64	0,46-0,79	1,70	0,99-2,91	0,58	0,33-1,02
≥3	13	23	10	0,36	0,21-0,54	0,90	0,74-0,96	0,77	0,50-0,92	0,59	0,44-0,72	3,45	1,06-11,25	0,72	0,53-0,97
≥4	7	12	5	0,18	0,08-0,36	0,93	0,78-0,98	0,71	0,36-0,92	0,54	0,40-0,67	2,59	0,55-12,27	0,88	0,72-1,08
≥5	6	11	4	0,14	0,06-0,32	0,93	0,78-0,98	0,67	0,30-0,90	0,53	0,40-0,66	2,07	0,41-10,43	0,92	0,77-1,10
≥6	2	4	1	0,04	0,01-0,18	0,97	0,83-0,99	0,50	0,01-0,91	0,51	0,38-0,64	1,04	0,07-15,77	1,00	0,91-1,10
≥7	1	2	0	0,00	0-0,12	0,97	0,83-0,99	0,00	0-0,79	0,50	0,37-0,63	0,00		1,04	0,97-1,11

Table 9: Diagnostic accuracy for mortality

MEWS	N	%	N mortality	Sensitivity	95% CI	Specificity	95% CI	PPV	95% CI	NPV	95% CI	LR+	95% CI	LR-	95% CI
≥1	49	84	6	0,86	0,49-0,97	0,16	0,08-0,28	0,12	0,06-0,24	0,89	0,57-0,98	1,02	0,74-1,41	0,91	0,13-6,23
≥2	30	52	6	0,86	0,49-0,97	0,53	0,40-0,66	0,20	0,10-0,37	0,96	0,82-0,99	1,82	1,20-2,77	0,27	0,04-1,69
≥3	14	24	4	0,57	0,25-0,84	0,80	0,68-0,89	0,29	0,12-0,55	0,93	0,82-0,98	2,91	1,25-6,81	0,53	0,22-1,27
≥4	8	14	3	0,43	0,16-0,75	0,90	0,79-0,96	0,38	0,14-0,69	0,92	0,81-0,97	4,37	1,33-14,42	0,63	0,33-1,21
≥5	7	12	2	0,29	0,08-0,64	0,92	0,82-0,97	0,33	0,10-0,70	0,90	0,79-0,96	3,64	0,81-16,36	0,78	0,48-1,25
≥6	2	3	1	0,14	0,03-0,51	0,98	0,90-1,00	0,50	0,10-0,90	0,89	0,79-0,95	7,29	0,51-103,83	0,87	0,65-1,19
≥7	1	2	0	0,00	0-0,35	0,98	0,90-1,00	0,00	0-0,79	0,88	0,77-0,94	0,00		1,02	0,98-1,06

Table 10: Individual parameters – Hospitalization

	N	(%)*	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Systolic blood pressure ≤ 100 mmHg	10	11	0,15	0,94	0,70	0,47	2,45	0,90
Systolic blood pressure ≥200 mmHg	1	1	0,03	1,00	1,00	0,54	∞	0,98
Heart rate ≤50 bpm	1	1	0,03	1,00	1,00	0,55	∞	0,97
Heart rate ≥101 bpm	24	27	0,36	0,82	0,67	0,55	1,96	0,79
Respiratory rate < 9 breaths per minute	0	0						
Respiratory rate > 14 breaths per minute	50	79	0,87	0,28	0,54	0,69	1,21	0,46
Temperature <35°C	0	0						
Temperature ≥38,5°C	5	9	0,04	0,86	0,20	0,48	0,26	1,12
AVPU: VPU	4	4	0,06	0,98	0,75	0,52	3,15	0,96
Neurological deficit: yes	5	5	0,08	0,98	0,80	0,52	4,15	0,94
Oxygen saturation <90%	9	13	0.17	0.92	0.67	0,52	2.13	0.90
Capillary refill >2 seconds	2	7	0,08	0,94	0,50	0,57	1,31	0,98

*Percentage of total recordings of this parameter.

Table 11: Individual parameters – Mortality

	N	(%)*	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Systolic blood pressure ≤ 100 mmHg	11	11	0,38	0,91	0,27	0,94	4,08	0,69
Systolic blood pressure ≥200 mmHg	1	1	0,00	0,99	0,00	0,94	0,00	1,01
Heart rate ≤50 bpm	1	1	0,00	0,98	0,00	0,92	0,00	1,02
Heart rate ≥101 bpm	24	26	0,38	0,74	0,13	0,92	1,46	0,84
Respiratory rate < 9 breaths per minute	0	0						
Respiratory rate > 14 breaths per minute	51	80	0,86	0,21	0,12	0,92	1,09	0,68
Temperature <35°C	0	0						
Temperature ≥38,5°C	5	9	0,17	0,92	0,20	0,91	2,17	0,90
AVPU: VPU	5	5	0,25	0,97	0,40	0,94	7,58	0,78
Neurological deficit: yes	5	5	0,00	0,94	0,00	0,91	0,00	1,06
Oxygen saturation <90%	10	14	0,29	0.88	0.20	0.92	2.38	0.81
Capillary refill >2 seconds	2	7	0,00	0,93	0,00	0,93	0,00	1,08

*Percentage of total recordings of this parameter.

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Appendix 1: Literature study

The MEDLINE database and the Cochrane Library were searched for articles concerning early warning scores in family practice. Search terms were “modified early warning score”; and “early warning score” in combination with “family practice” (MeSH term), “general practitioners” (MeSH term), “primary health care” (MeSH term) “out of hospital” or “prehospital”.

A first selection was made on title, then the articles were evaluated on their abstract. Studies regarding an early warning score in a family practice setting with adult patients were withheld. The details of the process are shown in **appendix table 1**.

Appendix table 1: Search methods

Database	Search term	Search result	Possibly suitable title	Articles withheld
Medline	*“modified early warning score”*	129 articles	6 articles	2 articles
	“early warning score” and *“family practice”* (mesh term)	0 articles		
	“early warning score” and *“general practitioners”* (mesh term)	0 articles		
	“early warning score” and *“out of hospital”*	31 articles	0 new articles	
	“early warning score” and *“prehospital”*	8 articles	0 new article	
	“early warning score” and *“primary health care”* (mesh term)	10 articles	1 new articles	1 article
The Cochrane Library	*“modified early warning score”*	11 articles	1 article	0 articles
	“early warning score”	1 article	1 article	0 articles
“ICHO (Interuniversitair Centrum voor HuisartsenOpleiding)” dissertation database	*“modified early warning score”*	1 article	1 article	1 article
	“early warning score”	2 articles	0 new articles	
			Total	**4 articles**

Four articles met the search criteria. Their main results are shown in **appendix table 2**.

Appendix table 2: Articles regarding an EWS in family practice

Reference	Study	Aim	Conclusion
Mols p, Vercruysse Y, de Villenfagne MA, et al. Approche rationelle et prise en charge du patient dyspnéique en médecine générale. Rev Med Brux 2015, 36: 335-342.	Continuing medical education paper	To describe the rational approach and management of the dyspnoeic patients in family practice.	The MEWS is proposed to assess the severity of the dyspneic patient's condition.
AmmitzbØll O, Maarslet L. Implementering af systematisk observationsmetode I primaersektoren er mulig. Ugeskr Laeger 2014, 176:2-4.	Prospective cohort study	To assess if the EWS is an appropriate tool to detect serious illness in an early stage in elderly patients. Is there a correlation between the EWS and physician's visits and hospital admissions?	The EWS in family practice is adequate to trace elderly in need of medical assistance. At a EWS ≤ 2, 6% were hospitalized. At a EWS ≥ 5 this number increased to 31%. At a EWS ≤ 2, 24% of the patients visited a doctor. At a EWS ≥ 5, 45% visited a doctor.
Venkatesan S, Myles PR, McCann G, et al. Development of processes allowing near real-time refinement and validation of triage tools during the early stage of an outbreak in readiness for surge: the FLU-CATs Study. Health Technology Assessment 2015, 19(89):	Prospective cohort study	Evaluating the performance of the triage tools 'CATs' and 'PMEWS' in predicting hospital admission and death in patients presenting with influenzalike illness to family doctors during inter-pandemic winter seasons.	There were too few outcome events from which to draw any conclusions regarding the performance of the triage tools.
Faes M. Is de Modified Early Warning Score bruikbaar in de huisartsengeneeskunde? Leuven: KU Leuven; 2015.	Prospectieve cohort study	Determining if the MEWS is a practical tool in family practice? Primary endpoint: hospitalization > 24h.	A MEWS ≥ 3 is a good predictor of hospitalization (sensitivity = 0.76; specificity = 0.92).

Appendix 2: Approved study protocol

KU LEUVEN

Biomedische Wetenschappen

Ethische begeleiding masterproeven

mp11278	Is de Modified Early Warning Score een goede screeningstool voor huisartsen?

Student(en):
Sophie Bakkers
Promotor:
Frank Buntinx (frank.buntinx@med.kuleuven.be - u0012319 - Acad. Centr. voor Huisartsgeneeskunde)
Hoofdonderzoeker:

Faculteit:
Geneeskunde
Opleiding:
Master in de huisartsgeneeskunde (Leuven e.a.)
Het onderzoek is:
multicentrisch
De opdrachtgever is:
academisch (universiteit,...)

Het onderzoek is:
Het onderzoek is (gedeeltelijk) prospectief.
Het onderzoek is:
Prospectief observationeel onderzoek
Gebruikte methode:
verzamelen van persoonsgegevens

Bijkomende gegevens:

Achtergrond:

De Modified Early Warning Score (MEWS) is een score om "achteruitgang te voorspellen". Gemeten in het ziekenhuis geeft een verhoogde MEWS een verhoogd risico op mortaliteit in het ziekenhuis of op opname op intensieve zorgen. Op de spoedgevallendienst geeft een verhoogde MEWS een verhoogde kans op opname en mortaliteit in het ziekenhuis weer.

De MEWS is gebaseerd op 5 gemakkelijk te meten parameters: systolische bloeddruk, hartslagfrequentie, ademhalingsfrequentie, AVPU-score, temperatuur. Dit maakt dat de MEWS bruikbaar is in een setting waar technische onderzoeken niet steeds voorhanden zijn, zoals mogelijks ook de huisartsenpraktijk. Het opzet van deze masterproef is om verder te gaan op het werk van Dr. Faes Michiel, die een eerste aanzet deed om de bruikbaarheid van de MEWS in de huisartsenpraktijk na te gaan.

Appendix 3: Approval of the ethical board

Betreft uw aanvraag Ethische begeleiding masterproeven met titel "Is de Modified Early Warning Score een goede screeningstool voor huisartsen?" (mp11278)

Martine Goossens <martine.goossens@kuleuven.be>

Thu 19/05/2016 14:37

To:Frank Buntinx <frank.buntinx@med.kuleuven.be>;

Cc:Sophie Bakkers <sophie.bakkers@student.kuleuven.be>;

English version below

Geachte Heer/Mevrouw

De Opleidingspecifieke Ethische Begeleidingscommissie van de opleiding "Master in de huisartsgeneeskunde (Leuven e.a.)" heeft uw voorstel tot Masterproef "Is de Modified Early Warning Score een goede screeningstool voor huisartsen?" onderzocht en gunstig geadviseerd. Dit betekent dat de commissie van oordeel is dat de studie, zoals beschreven in het protocol, wetenschappelijk relevant en ethisch verantwoord is. Dit gunstig advies van de commissie houdt niet in dat zij de verantwoordelijkheid voor de geplande studie op zich neemt. U blijft hiervoor zelf verantwoordelijk. Indien u van plan bent uw masterproef te publiceren kan deze e-mail dienen als bewijs van goedkeuring.

Dear Mr/Ms

The Supervisory Committee on Medical ethics of the "Master in de huisartsgeneeskunde (Leuven e.a.)" programme has reviewed your master's thesis project proposal "Is de Modified Early Warning Score een goede screeningstool voor huisartsen?" and advises in its favour. This means that the committee has acknowledged that your project, as described in the protocol, is scientifically relevant and in line with prevailing ethical standards. This favourable advice does not entail the committee's responsibility for the planned project, however. You remain solely responsible. If you intend to publish your master's thesis, this e-mail may be used as proof of the committee's consent.

Met vriendelijke groeten

Opleidingsspecifieke begeleidingscommissie van de opleiding Master in de huisartsgeneeskunde (Leuven e.a.)