The best Early Warning Scores to predict important outcomes among ED patients

William Spencer[1], Jesse Smith[1], Patrick Date[1], Erik de Tonnerre[1], David Taylor[1,2]

University of Melbourne
Emergency Department, Austin Hospital

Austin Health

THE UNIVERSITY OF MELBOURNE

Background

Early Warning Scores (EWS):

- identify patients at risk of adverse outcomes
  - e.g. TRISS injury severity score
- many based mainly on physiological data
  - e.g. qSOFA for sepsis
    - Worthing Physiological Score
- the best general purpose EWS are unknown

Background

Goodacre Score 2006

(scores 0-14)

Variable	0	+1	+2	+3	+4	+5	+6
GCS	>13	11-13	8-10	5-7	<5		
HR	>89	86-89	-	75-85	<75		
Age	<45	-	45-54	55-64	-	65-74	>74

Background

VitalPac Early Warning Score (ViEWS)

(scores 0-21)

Variable	+3	+2	+1	0	+1	+2	+3
RR	≤8		9-11	12-20		21-24	≥25
SaO_2	≤91%	92%-93%	94%-95%	≥96%			
Suppl O_2	Yes	-	-	No			
Temp °C	≤35.0	-	35.1-36.0	36.1-38	38.1-39	≥39.1	-
SBP	≤90	91-100	101-110	111-249	≥250	-	-
HR		≤40	41-50	51-90	91-110	111-130	≥131
AVPU				A			V, P, U

Background

Objective:

- directly compare 13 EWS in a single patient cohort
- determine which best predicts important outcomes:
  - admission to hospital
  - admission to ICU within 2 days
  - clinical deterioration within 2 days (MET/Code Blue)
  - mortality within 2 days
- ‘app’ development for flagging patients at risk

Methods

- prospective cohort study
- Austin Hospital ED
  - metropolitan, tertiary referral centre
  - annual (mixed) patient census ~90,000
- February-May 2018
- approved by the Austin Ethics Committee

Methods

Inclusion Criteria:

- uses mainly physiological data
- generates a numerical score
- designed to predict a clinical outcome(s), including death
- had been used in the ED or similar setting e.g. AAU

Exclusion Criteria:

- used for a specific clinical presentation e.g. sepsis
- used for patient subpopulations e.g. psychiatric
- requires use of pathology test data
- requires use of history or examination findings
- requires data not routinely collected e.g. urine output

Early Warning Scores examined

EWS	Population of derivation	Outcomes predicted
WPS	ED Patients	Mortality
VSS	ED Patients	Mortality
MEWS GCS	ED Patients	Mortality, Admission, Disposition
REMS	ED Patients	Mortality, Length of Stay
VSG	ED Patients	Mortality, Admission, MET Calls
Goodacre	ED Ambulance Patients	Mortality
GAP	ED Trauma Patients	Mortality
RAP	Crit. Care Pre-Hospital Patients	Mortality
MEWS	Medical Admission Patients	Mortality, ICU or HDU, Cardiac Arrest
Groarke	Medical Admission Patients	Mortality, ICU, Cardiac Arrest, LOS
ViEWS	Medical Admission Patients	Mortality (24-hour)
AbViEWS	Medical Admission Patients	Mortality (48-hour)
NEWS	Medical Admission Patients	Mortality (24-hour), ICU, Cardiac Arrest

Methods

- single data collector
- convenience sampling (08:00-18:00, weekdays)
- consecutive adult patients in the ED cubicles
- 13 EWS scores calculated
- outcomes extracted from the record after 28 days:
  - admission to hospital
  - admission to ICU within 2 days
  - clinical deterioration within 2 days (MET call/Code Blue)
  - mortality within 2 days

Methods

Data Analysis:

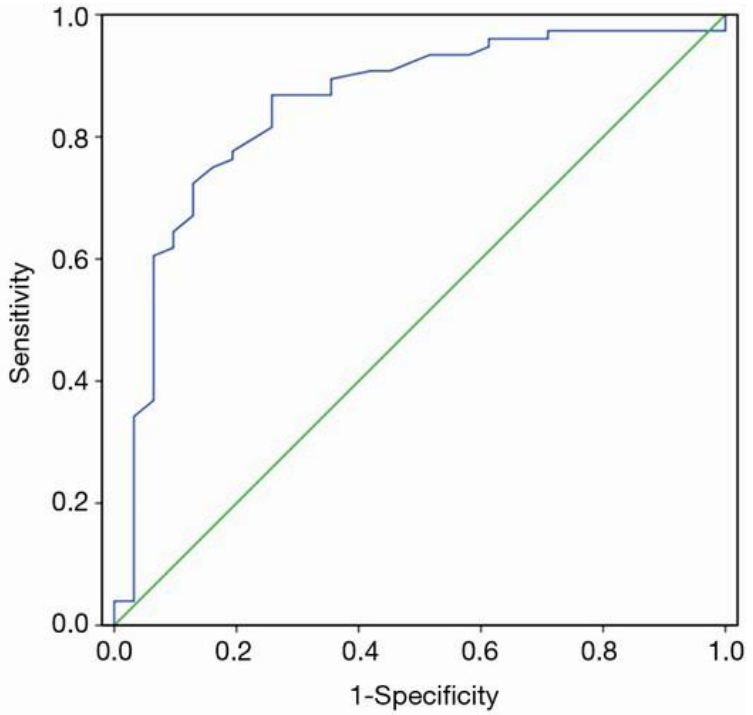
Area under the Receiver Operator Characteristic curve (AUROC)

- evaluate sensitivity & specificity at each score level
- area reflects the overall predictive ability of the score

Methods

Data Analysis:

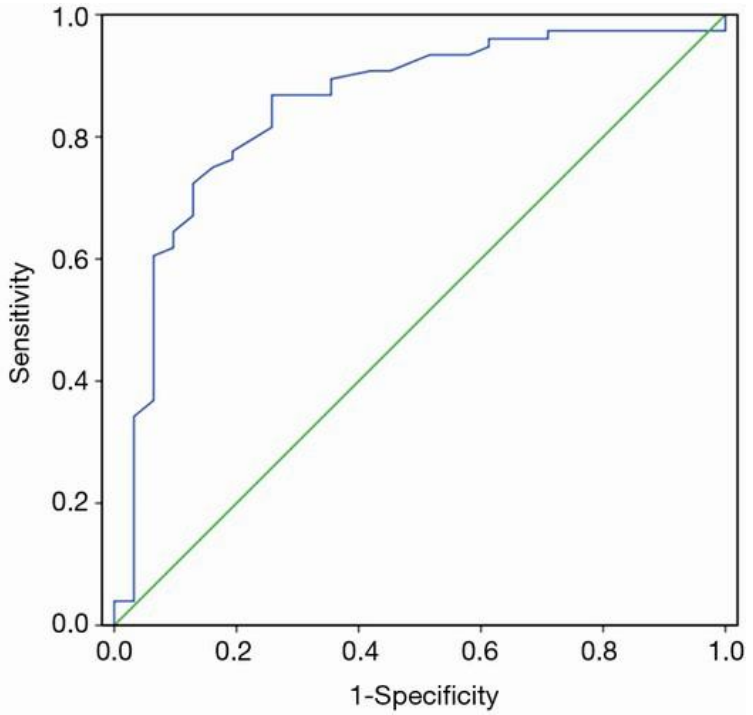
Area under the Receiver Operator Characteristic curve (AUROC)

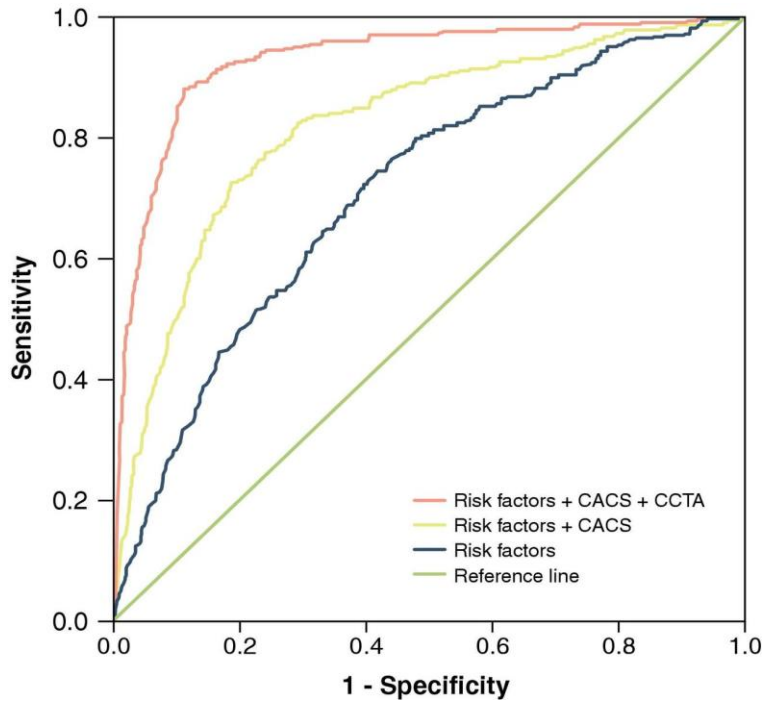


Methods

Data Analysis:

Area under the Receiver Operator Characteristic curve (AUROC)





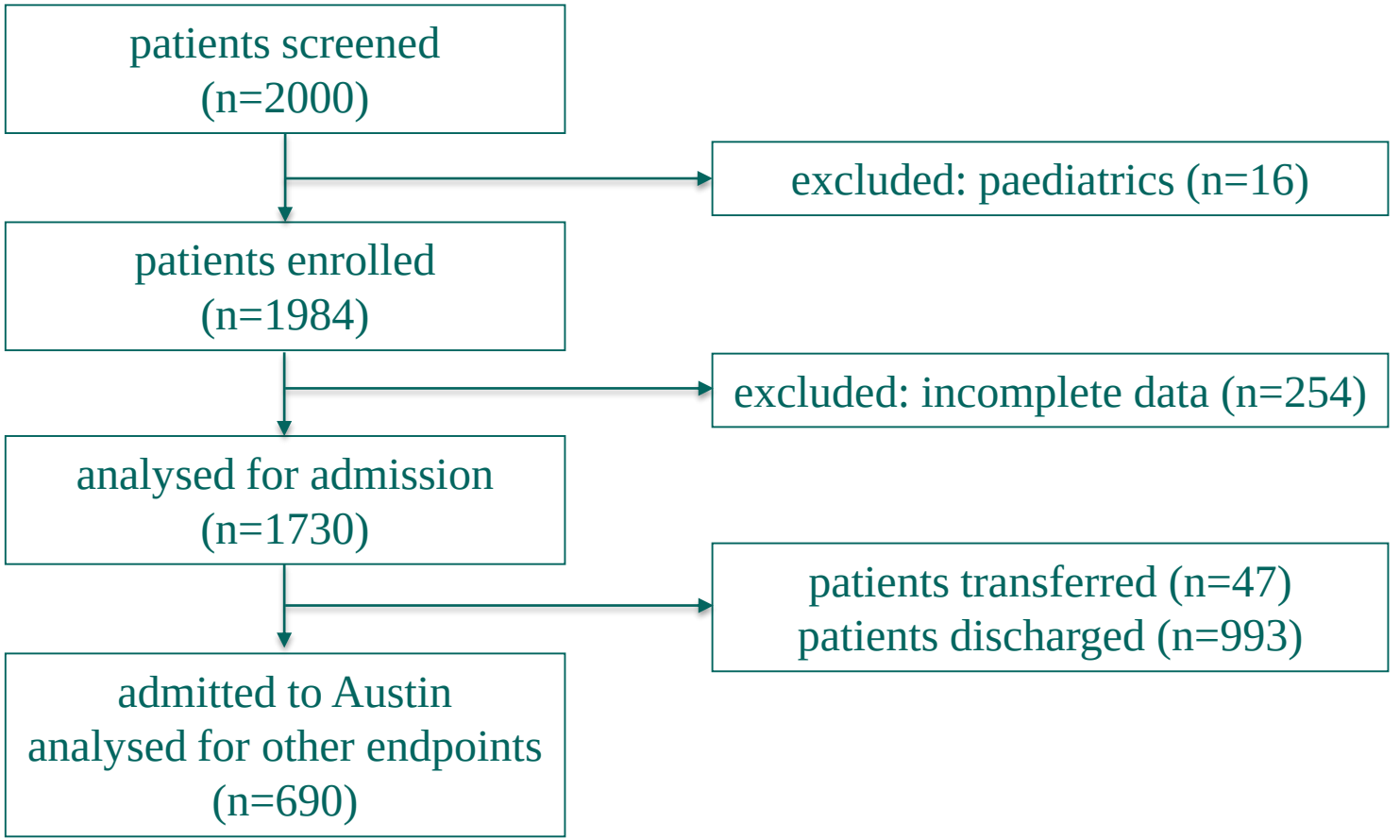
Methods

Classification of predictive AUROC accuracy:

- 0.90-1.00 = excellent
- 0.80-0.90 = good
- 0.70-0.80 = fair
- 0.60-0.70 = poor
- 0.50-0.60 = fail

Results

Recruitment Flow Diagram



Results: Admission to hospital

EWS	AUROC	(95% CI)
MEWS GCS	0.68	(0.66-0.71)
Groarke	0.68	(0.65-0.70)
ViEWS	0.68	(0.65-0.70)
AbViEWS	0.68	(0.65-0.70)
WPS	0.68	(0.65-0.70)
NEWS	0.68	(0.65-0.70)
REMS	0.65	(0.63-0.68)
MEWS	0.65	(0.62-0.68)
Goodacre	0.65	(0.62-0.67)
GAP	0.65	(0.62-.067)
all others (range)	0.62-0.51	

Results: Admission to ICU within 2 days

EWS	AUROC	(95% CI)
WPS	0.72	(0.62-0.81)
Groarke	0.70	(0.58-0.82)
MEWS GCS	0.69	(0.57-0.81)
AbViEWS	0.69	(0.56-0.83)
MEWS	0.69	(0.56-0.82)
NEWS	0.69	(0.55-0.82)
ViEWS	0.69	(0.55-0.82)
VSS_{MAX}	0.66	(0.53-0.79)
RAPS	0.63	(0.51-0.76)
$VSS_{INITIAL}$	0.62	(0.49-0.75)
all others (range)	0.60-0.51	

Results: Deterioration within 2 days

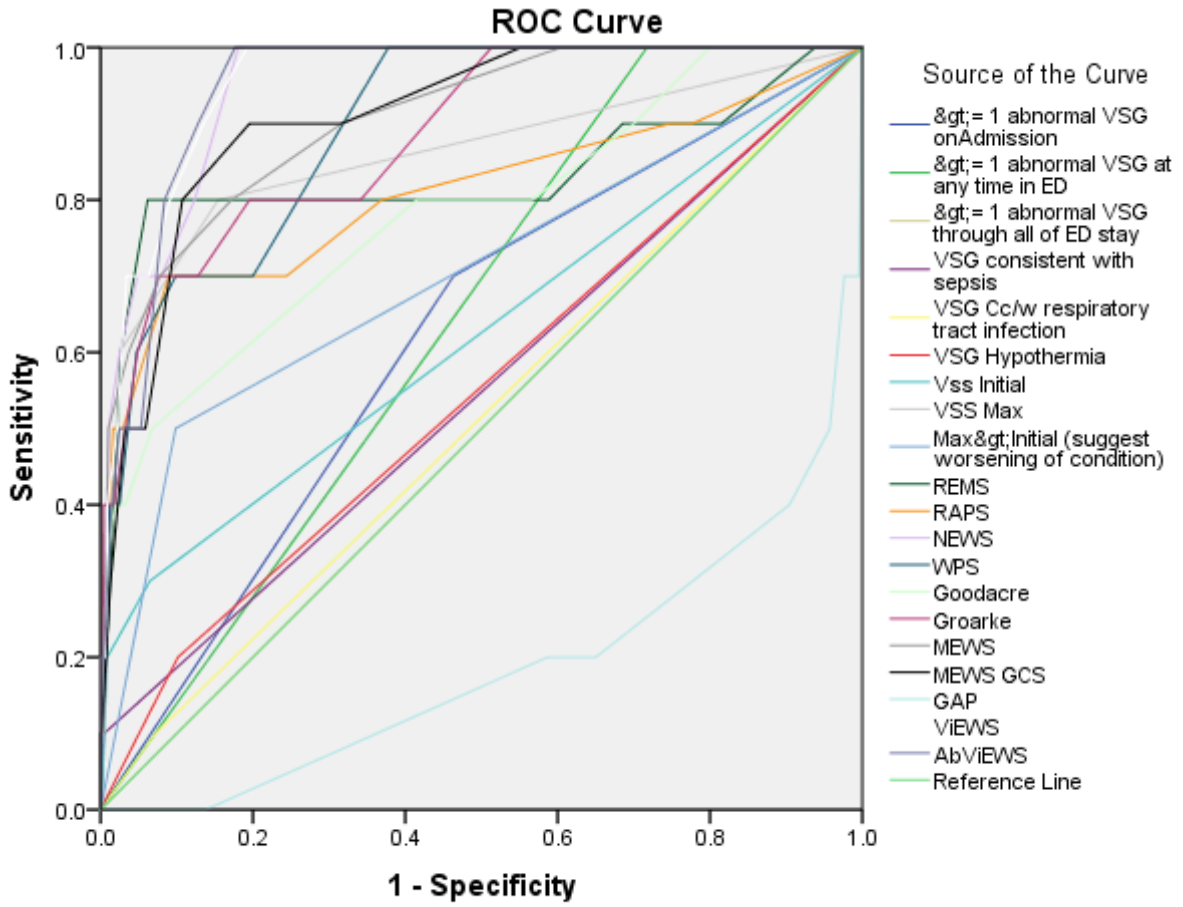
EWS	AUROC	(95% CI)
MEWS GCS	0.70	(0.61-0.79)
MEWS	0.69	(0.60-0.79)
Groarke	0.69	(0.59-0.78)
WPS	0.66	(0.56-0.75)
NEWS	0.65	(0.54-0.76)
ViEWS	0.65	(0.54-0.75)
AbViEWS	0.64	(0.53-0.75)
RAPS	0.62	(0.52-0.72)
VSS_{MAX}	0.62	(0.51-0.72)
REMS	0.61	(0.51-0.71)
all others (range)	0.60-0.54	

Results: Mortality within 2 days

EWS	AUROC	(95% CI)
ViEWS	0.96	(0.92-0.99)
NEWS	0.95	(0.91-0.99)
AbViEWS	0.95	(0.92-0.98)
MEWS GCS	0.91	(0.83-0.99)
MEWS	0.91	(0.82-1.00)
WPS	0.90	(0.82-0.98)
Groarke	0.89	(0.79-0.99)
VSS_{MAX}	0.86	(0.71-1.00)
REMS	0.83	(0.65-1.00)
GAP	0.81	(0.66-0.97)
all other (range)	0.81-0.62	

Results

Mortality within 2 days: all EWS

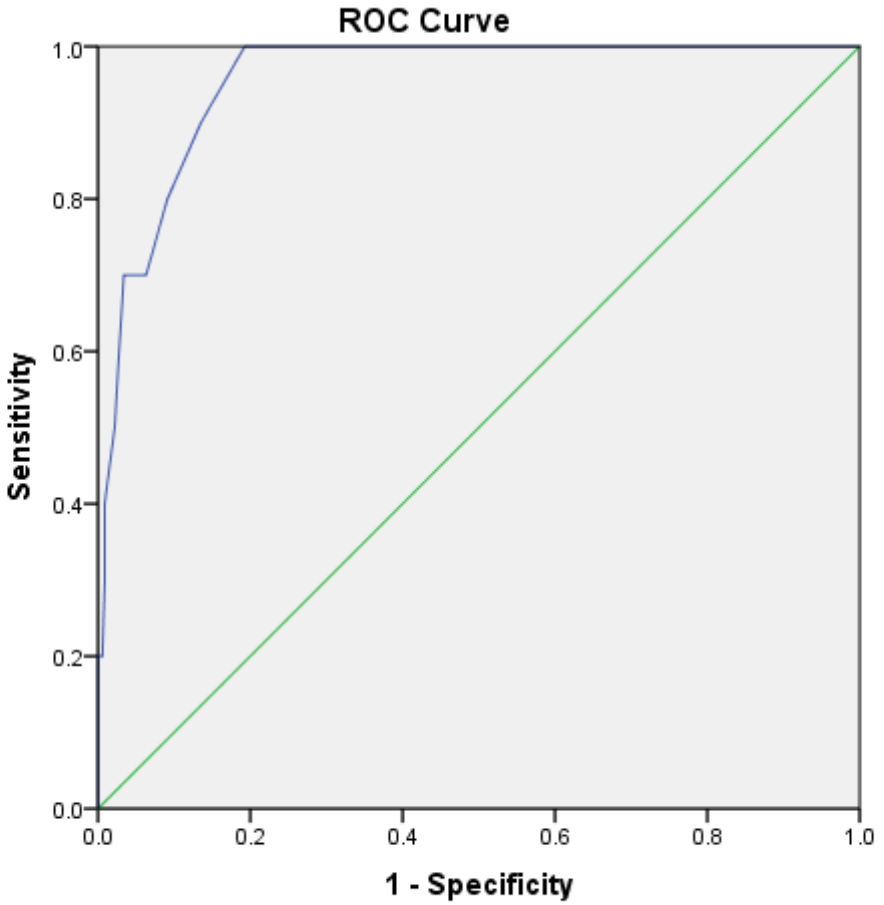


Diagonal segments are produced by ties.

Austin Health

Results

Mortality within 2 days: ViEWS



Diagonal segments are produced by ties.

Austin Health

Discussion

- The usefulness of EWS is limited for:
  - Admission to hospital
  - Admission to ICU within 2 days
  - Clinical deterioration within 2 days

- Some EWS are highly predictive of mortality at 2 days
- Scores automatically calculated from electronic data
- Patients at risk of death flagged
- Inform optimal care and may change management

Discussion

Components of the best 3 EWS:

EWS	RR	SaO_2	Suppl O_2	Temp	SBP	HR	AVPU
ViEWS							
NEWS							
AbViEWS							

Discussion

Components of the best 3 EWS:

EWS	RR	SaO_2	Suppl O_2	Temp	SBP	HR	AVPU
ViEWS	✓	✓	✓	✓	✓	✓	✓
NEWS	✓	✓	✓	✓	✓	✓	✓
AbViEWS	✓	✓	✓	✓	✓	✓	-

Discussion

AbViEWS

Austin Health

Discussion

AbViEWS

Discussion

AbViEWS

WARNING

Austin Health

Discussion

AbViEWS

WARNING

re-evaluation

Austin Health

Summary

AbViEWS has the potential to:

- Analyse routinely collected vital sign data
- Flag patients at risk of death
- Inform patient care:

Summary

AbViEWS has the potential to:

- Analyse routinely collected vital sign data
- Flag patients at risk of death
- Inform patient care:
  - Prognosis
  - Communication with patient and family
  - Advanced Care Planning
  - Communication with fellow clinicians
  - Level of care and disposition e.g. ward vs high dependency vs ICU
  - Management change e.g. drug selection, invasive Rx