

## Original Research Article


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### 3 **Poor Responses to Patients' Deteriorating Physiological Parameters in Hospital: The** 4 **Roles of Modified Early Warning Scoring System and Rapid Response System**


5 *"A stitch in time saves nine"* 


#### 6 **ABSTRACT**

7 **Background.** Most adverse events in hospitalised patients are often preceded by documented  
8 progressive deterioration of physiological parameters without appropriate responses. Modified Early  
9 Warning Score (MEWS) is a simple physiological score that was developed to aid early recognition of  
10 patient at risk of deterioration and assist in timely response.

11 **Aim:** To document and determine responses of health care workers to physiological parameters 72  
12 hours preceding death and to sensitise and convince nurses and doctors about this simple scoring  
13 system. 

14 **Methodology:** We reviewed case notes of 264 patients discharged alive and 243 dead patients in  
15 Ladoke Akintola University of Technology Teaching Hospital Ogbomosho. Patients less than 18 years  
16 old and obstetrics and gynaecological patients were excluded. The Patients' relevant data and vital  
17 signs were gotten from case notes and were used to calculate Mean MEWS for each patient over 72  
18 hours preceding outcome. 



19 **Results.** One hundred and fourteen (79.72%) of 143 patients with MEWS of above six were classified  
20 to be critically ill and managed in general wards. Mean MEWS among the patients discharged alive  
21 was statistically significant lower than the dead patients ( $2.7 \pm 0.7$  vs.  $8.0 \pm 2.6$ ,  $P < .001$ ). Mean MEWS  
22 for pulse rate ( $0.2 \pm 0.63$  vs.  $2.1 \pm 1.0$   $P < .001$ ) and respiratory rate ( $1.2 \pm 0.01$  vs.  $2.3 \pm 0.75$ ,  $P < .001$ )  
23 were statistical significantly lower for the patients discharged alive. The main reason for calling  
24 attention of clinicians to deteriorating patients was gasping in 52.6% of cases. Responses of house  
25 officers when called upon to review critically ill patients were to inform registrars in 44.03% of cases.  
26 There was a mean delay of 131 ( $\pm 66.28$ ) minutes between house officers' review and consultants'  
27 inputs. 

28 **Conclusion:** Our study showed delay in recognition of patients at risk of deterioration and significant  
29 delay in decision making process, we thus suggest use of MEWS and introduction of rapid response  
30 system. 

31 **Keywords:** *Poor response, deterioration, physiological parameters, modified early warning score,*  
32 *Rapid response system.*


### 33 INTRODUCTION

34 National Early Warning Score (NEWS) is a simple physiological score that consists of six  
35 physiological parameters: pulse rate (PR) in beat per minute, systolic blood pressure (SBP) in  
36 millimetres of mercury, respiratory rate (RR) in breath per minute, temperature (T) in degree Celsius  
37 and arterial oxygen saturation (SpO<sub>2</sub>) and level of consciousness using AVPU system: (A alert, V for  
38 responding to voice, P responding to pain and U for unresponsive). This scoring system requires  
39 simple monitoring devices that can be done at bed side during routine monitoring of vital signs. The  
40 scoring system was developed by the Royal College of Physicians (RCP) to aid early recognition of  
41 patients at risk of adverse events, through tracking of patients' physiological parameters [1]. A variant  
42 of NEWS called Modified Early Warning Score (MEWS) excluded SpO<sub>2</sub> in its parameters, which  
43 makes it more easily scored as SpO<sub>2</sub> is not routinely monitored during vital signs assessment, a  
44 modification making it more feasible to use in low and middle income countries where pulse oximeter  
45 may not be readily available. Deterioration of patients' conditions are often preceded by progressive  
46 derangement of physiological parameters several hours prior to adverse events in about 80% of  
47 cases [2] which are often documented [3, 4, 5, 6, 7, 8, 9] without corresponding early competent  
48 clinical response and intervention [10]. Failure of early response and appropriate interventions from  
49 physicians with appropriate clinical competencies has been termed "*failure to act*" by Hillman et al and  
50 was associated with exacerbation of acute illness [11] with increased risk of cardio-respiratory arrest  
51 and death [12, 13] with a study quoting about 11% mortality [14]. Sub-standard care received by most  
52 of patients prior to presentation, due to poor health care services in low and middle income countries,  
53 are often associated with poorer prognosis and outcomes. This coupled with delay initiation of  
54 definitive treatment, delay recognition of progressive derangement of vital signs, lack of continuous  
55 automated monitoring devices in most of the wards and lack of dedicated acute medical teams for 24  
56 hours coverage in a day in many hospitals in most low and middle income countries, further escalate  
57 the poorer outcome seen in our patients. Early recognition of at risk patients makes it easier to  
58 manage such patients with simple measures such as oxygen support, fluid support, review of  
59 medications such as early commencement of antibiotics in patient with sepsis, with minimal cost on  
60 scarce health care resources.

61 The triad of early detection, timeliness of response and activation of clinicians with appropriate clinical  
62 competency has been shown to improve the outcomes of patients at risk of adverse events in  
63 hospitals. In other  achieve this triad many hospitals have introduced Rapid Response System  
64 (RRS) that consists of two limbs; the afferent limb that utilises a track and trigger systems (TTS) by  
65 using a scoring system such as National Early Warning Score or its modification called Modified Early  
66 Warning Score (MEWS) that will assist early recognition of patients at risk and the efferent limb  
67 system known as Rapid Intervention Team (RIT) that respond to afferent limb activation. This study  
68 was borne out of recognition of the advantages and effectiveness of compliance to triad of early  
69 detection, timeliness of response and competent clinical response in patients' care. We thus   
70 investigated our compliance to the triad, by documenting responses of health care workers to  
71 patients' physiological parameters 72 hours preceding discharge or death, to compare MEWS  
72 between dead patients and patients discharged alive, and to sensitise and convince health care  
73 workers that are directly involve in patients' care about this simple scoring system (MEWS) and its  
74 value in achieving the triad.

## 75 **METHODS**

### 76 **Setting**

77 The study was carried out in Ladoke Akintola University of Technology Teaching hospital Ogbomoso.  
78 Ladoke Akintola University of Technology Teaching hospital Ogbomoso is a new tertiary health care  
79 centre with facilities for primary, secondary and tertiary health care services. The hospital receives  
80 referral from local peripheral hospitals and neighbouring teaching hospitals. The hospital admits an  
81 average of about 2150 patients per year with mortality rate of about 5.60% per year on the average.  
82 The hospital has about 300 beds, an intensive care unit (ICU): with four functioning ventilator, two  
83 consultant anaesthesiologists, six anaesthetic specialist registrars in training and eight- non-specialist  
84 nurses. The hospital has minimal facilities for managing critically ill patients; making many critically ill  
85 patients to be managed in general wards by the managing team with or without contributions from the  
86 anaesthetist, a finding comparable to Bha jee study, who found out that critically ill patients are  
87 often managed in general wards in low and middle income countries due to few numbers of available  
88 ICU beds [15]. No ward in the hospital has facility for either continuous monitoring of patients  
89 physiological parameters or functioning defibrillator.

90

**91 Patients**

92 We retrospectively reviewed randomly selected case notes of 264 patients discharged alive and 243  
93 dead patients admitted between July 2011 and June, 2016. The exclusion criteria included patients  
94 less than 18 years, pregnant patients because pregnancy constitutes a risk on its own and NEWS and  
95 MEWS are yet to be validated in pregnant women and case notes that lack necessary parameters for  
96 calculating MEWS on six occasions preceding outcomes.

**97 Data**

98 The data collected included patients' socio-demographic characteristics, clinical diagnosis, patients'  
99 wards, and six-sets of each patients' vital signs at 12 hours interval over 72 hours preceding outcome  
100 (discharged alive or death). The obtained vital signs were used to calculate six sets of modified early  
101 warning score and mean score for each patient. Modified Early Warning Score of five was taken as  
102 critical value based on previous finding which showed that MEWS of 5 and above was associated  
103 with increased need for ICU admission (OR 5.4, 95% CI 2.8-10.7) and adverse outcome [16]. The  
104 mean score for patients that were discharged alive was compared to that of dead patients. The other  
105 data retrieved from the case notes included documented nurses' responses to abnormal vital signs,  
106 evidence of escalation of treatment or intervention either by the nurses or house officers when called  
107 upon, reason(s) for calling the attention of clinicians by nurses prior to patients death, house officers  
108 responses and treatment plans, time difference in minutes between house officers' documentation  
109 and registrars' documentation, registrars' documentation and consultants' input; time of death and  
110 duration of hospital stay.

**111 Modified Early warning Score (MEWS)**

112 Modified Early Warning Score is a modification of the National Early Warning Score developed by the  
113 Royal College of Physicians (RCP) with the aim of achieving a universal and objective scoring system  
114 that will allow early recognition of patients at risk of adverse events. National Early Warning Scoring  
115 system scores seven physiological parameters that include PR, SBP, RR, SpO<sub>2</sub>, T, consciousness  
116 and urine output (which is excluded from score calculation), whereas Modified Early Warning Scoring  
117 system excluded SpO<sub>2</sub> and Urinary Output (table 1) that are not routinely monitored and charted in  
118 vital signs charts. MEWS has minimum and maximum values of 0 and 14 respectively with higher  
119 score signifying physiological instability.

120

121

Table1: showing the component of Modified Early Warning Score and grading.

	3	2	1	0	1	2	3
Systolic blood pressure (mmHg)	70	71-80	81-100	101-199		>200	
Pulse rate (beats per minute)		40	41-50	51-100	101-110	111-129	130
Respiratory rate (breaths per minute)		9		9-14	15-20	21-29	30
Temperature (°C)		35		35-38.4		38.5	
AVPU score				A	V	P	U

122

123 AVPU: A, alert; V, responding to voice, P, responding to pain; U, unresponsive

124 Adapted from Subbe et al, 2001. doi:10.1371/journal.pone.0151408.t001 [16].

125

126 **Statistical analysis**

127 Results were presented in form of tables and charts. Socio-demographic characteristics were  
 128 analysed using descriptive statistics, categorical variables were presented in form of both frequencies  
 129 and percentages, and mean and standard deviation were used for continuous variables. Chi-square  
 130 and t- test were used for test of significance for categorical and continuous variables respectively. *P*-  
 131 values less than .05 were considered to be statistically significant.

132

133 **RESULTS**

134 Case notes of 264 patients discharged alive and 243 dead patients were reviewed. The mean age of  
 135 the patients was 49.6 (±26.7) with age ranging from 18 and 105 years. Two hundred and eighty nine  
 136 (57.0%) of the patients were males. Table 2 shows the socio demographic characteristics of the  
 137 patients.

138

Table 2: Showing the socio-demographic characteristics of the patients

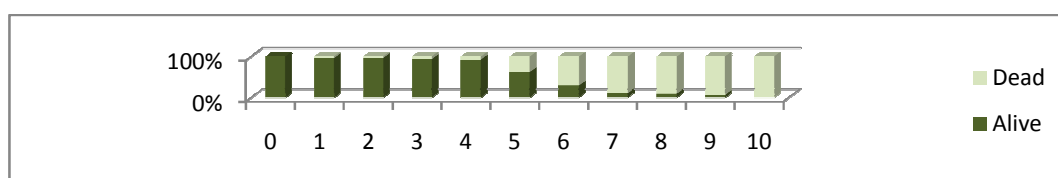
Parameters	Alive (n=264)	Dead (n=243)	<i>P value</i>
Age (mean SD)	48.33(±28.2)	50.80(±26.2)	.3080
Sex M:F	153:111	136:107	.7175
<b>Wards</b>			

<b>Medical</b>	91	88	
<b>Surgical</b>	101	83	.5782
<b>ICU</b>	13	18	
<b>Emergency</b>	59	54	

139

140 Mean modified early warning score for patients discharged alive (PDA) was 2.7 ( $\pm$  0.6) as compared  
 141 to mean score of 8.0 ( $\pm$  2.6) for the dead patients ( $p < .001$ ). Further assessment revealed that  
 142 modified early warning score of 5 and above were significantly associated with higher risk of mortality  
 143 (RR 21.24,  $P < .001$ ) (Fig. 1)

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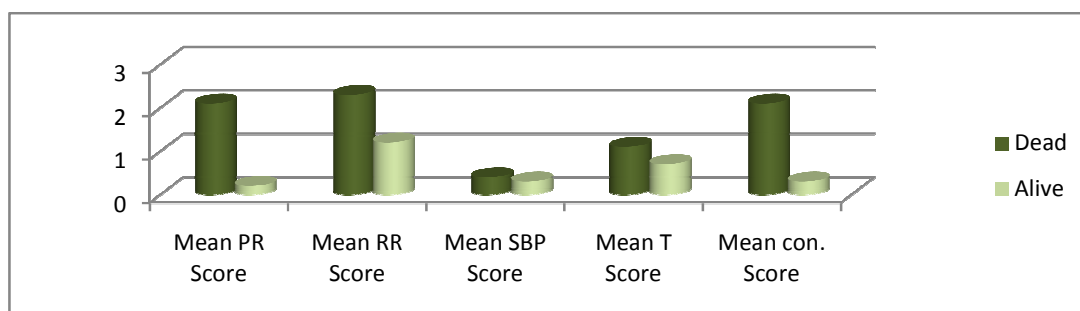


145

146 Fig.1: Showing the outcomes in percentages for different modified early warning score values.

147 Assessment of vital signs revealed that pulse rate, respiratory rate, temperature and consciousness  
 148 scores were statistically significantly higher in dead patients, while systolic blood pressure shows no  
 149 statistical significant difference when dead and alive patients were compared.

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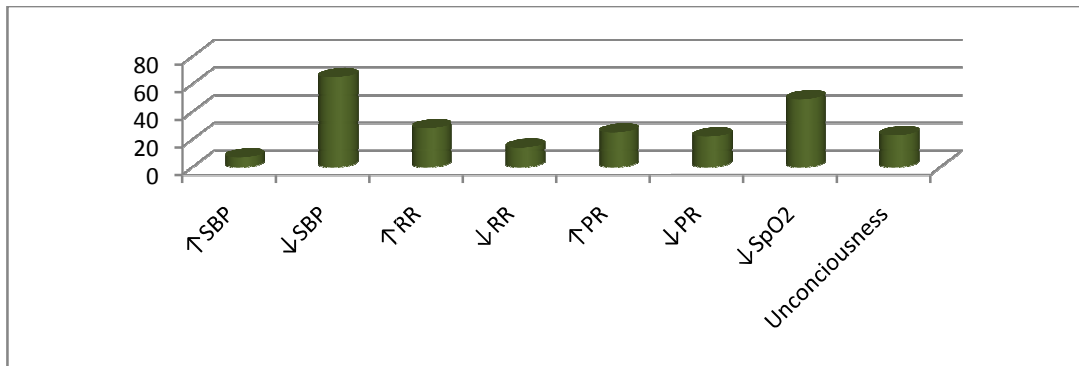


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152 Fig.2: Showing the mean scores for each parameter of MEWS between dead and alive patients.

153 Ninety-four (26.2%) out of 361 patients that have MEWS of 6 and below had documented evidence  
 154 of escalation of treatment or increased in frequency of monitoring of their vital signs as compared to  
 155 139 (95.2%) out of 146 patients with MEWS of greater than seven. Decreased blood pressure in 65  
 156 (30.4%) occasions was responsible for escalation of treatment based on the vital signs and followed  
 157 by decreased SpO<sub>2</sub> in 49 (22.9%) occasions (Fig. 3).

158



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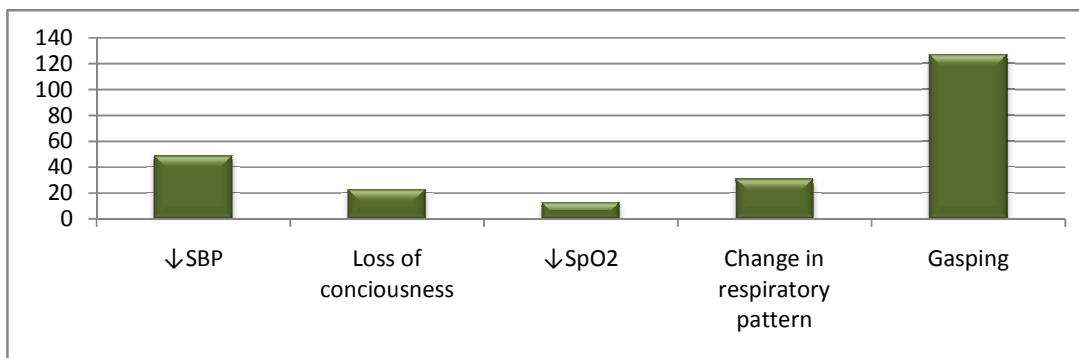
160 Fig. 3: Showing changes in vital signs that were associated with escalation of treatment.

161 ↑ *Increased*     ↓ *Decreased*

162 There was a mean delay of eighty-three minutes between house officers' documentation and  
 163 registrars' review following recognition of patients' deterioration by ward nurses and mean delay of  
 164 about forty-eighty minutes before consultants' input, making a total delay of 131 minutes before final  
 165 decisions were taken.

166 Analysis of indication for notifying clinicians prior to patients' demise revealed that in 52.6% of times  
 167 attentions of clinicians were not drawn to patients until patients started gasping. (Fig. 4)

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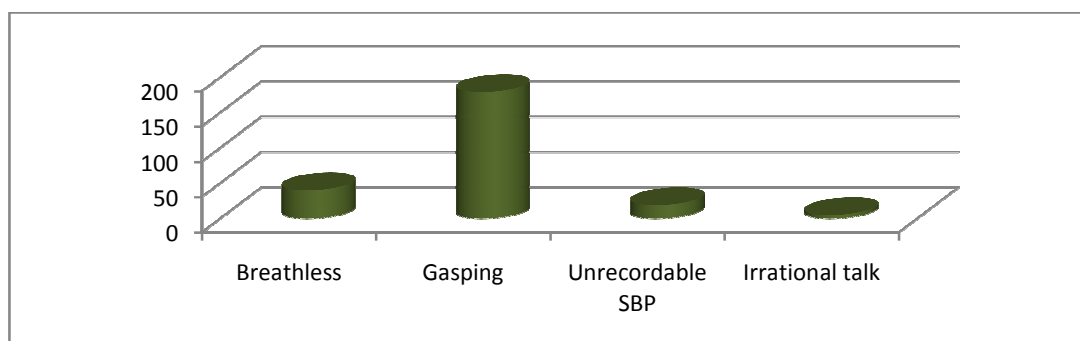


169

170 Fig.4: Reasons for notifying managing team preceding patients' death by nurses

171 Review of the case notes revealed that in 179 (73.7%) out of 243 occasions clinicians met patients  
 172 gasping and breathless in 40 (16.5%) occasions. (Fig. 5)

173

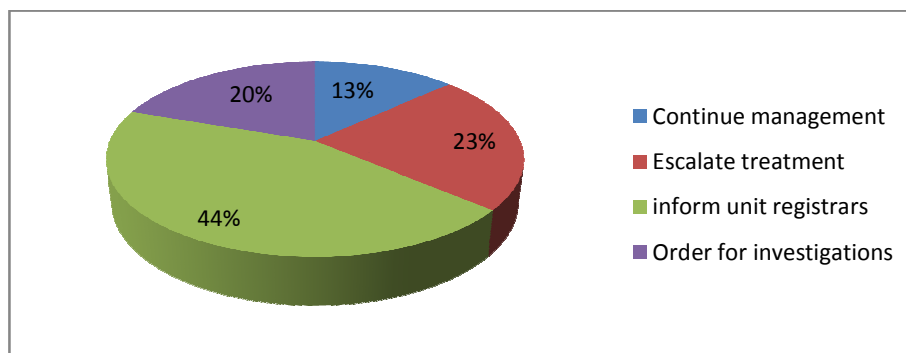


174

175 Fig.5: Showing patients' condition at point of review by clinicians following notification of patients'  
 176 deterioration by the nursing staffs

177 When house officers were informed to review patients following recognition of patients' deterioration;  
 178 in 107(44.03%) occasions the response were to inform their unit registrars. (Fig. 6)

179



180

181 Fig.6: Showing the pattern of house officers' responses to deteriorating patients.

182 Admission pattern revealed that 311 (61.3%) out of 507 patients had MEWS of 5 and above. Of 311  
 183 patients with MEWS of 5 and above 280 (90.0%) were managed in general wards. Only 29 (20.3%)  
 184 out of the 143 patients with MEWS of seven and above were managed in ICU.

185 In none of the case notes was there cleared documentation by clinicians on what to do in case of  
 186 patients' deterioration or specific value of vital signs that clinicians should be informed.

187 **DISCUSSION**

188 Our study confirmed previous reports findings on MEWS as a predictor of patients' outcome; and that  
 189 progressive deterioration of patients' physiological parameters often precede patients' death, which  
 190 are often documented without appropriate corresponding competent clinical responses. Our study  
 191 showed that modified early warning scores of five and above was associated with clinical and  
 192 statistical significant mortality. No patients in our study with mean modified early warning score of



193 above eight and those with MEWS of above twelve at any point survived, as compared to one study  
194 where some patients with such values survived [17]. Possible explanation for this is poor outcome in  
195 our study is probably due to lack of adequate critical care facilities in our centre such as: all round  
196 functioning ICU, high dependency unit (HDU) and complete lack of coronary-cardiac unit compared to  
197 hospitals in developed countries where modern critical care facilities are readily available and  
198 accessible. Other factors that may be responsible for better outcomes in developed countries are:  
199 availability of services of emergency medical team (EMT) and activation of rapid response system  
200 (RRS) following recognition of patients' deterioration [18]. Our study also found out that there was  
201 appreciable mean delay of about 131 minutes before consultants' inputs into patients' management  
202 following recognition of deterioration by nursing staffs. A non documented observation by one of the  
203 authors revealed that in about 56% of cases randomly reviewed consultants' input were often verbal  
204 communications over the phone, this rose up to about 95% during the call hours. This time delay  
205 becomes more worrisome as it was revealed that house officers' responses in most cases were  
206 inadequate and sub-optimal due to lack of adequate knowledge and experiences on management of  
207 critically ill patients. In majority of the cases house officers rarely escalate treatments when called  
208 upon to review patients at risk of deterioration, but rather waited for their registrars to take decisions  
209 who in turn would further need to inform managing consultants before major decisions are taken such  
210 as: need to transfer patients to higher care unit or refers to other centre with better facilities.  
211 This study revealed that common reasons for escalation of treatment were decrease in blood  
212 pressure (un-recordable) followed by decreased SpO<sub>2</sub>; these two changes are late signs as initial  
213 compensatory mechanism of cardio-respiratory system would have maintained systemic blood  
214 pressure and SpO<sub>2</sub> by increasing HR, force of contraction, peripheral vasoconstriction and RR due to  
215 activation of sympatho-adrenergic response (Marey's reflex). This shows lack of basic understanding  
216 of pathophysiological changes and physiological compensatory mechanism associated with  
217 haemodynamic instability among health care workers.

218 The study showed poor compliance to the triad of early detection, timeliness of response and  
219 activation of appropriate clinicians with competent clinical responses which are important factors that  
220 influence patients' outcomes. We also found out that about 62% of patients in medical and surgical  
221 wards were considered to need at least an hourly monitoring of vital signs based on the expected  
222 response for MEW score of 5 as in the Royal College of Physicians (RCP) guidelines (Table 3). The

223 study further showed that less than one-fifth of patients with MEWS of seven and above were  
224 managed in intensive care unit ( ICU). This showed that significant percentage of patients that were  
225 managed in conventional general wards were patients that required higher care units. The main  
226 reasons for this pattern of admissions and management of “potential critically ill patients” in  
227 conventional general wards were due to: (1) failure of recognition for need to transfer such patients to  
228 higher care units with better monitoring facilities such as high dependency unit or ICU (2) lack of such  
229 higher units. Similar reasons were reported from studies from some other low income countries [19  
230 20].

231 In none of the case notes was clear documentation of what to do in case of patient’s deterioration of  
232 vital signs or change in patient’s clinical condition. The authors believed that if the clinicians clearly  
233 stated critical/specific vital sign values that clinicians’ attention should be sought and possibly what to  
234 do while waiting for clinicians’ review, some adverse events would have been prevented. A similar  
235 approach is being used in management of head injured patients when decrease in Glasgow Coma  
236 Score (GCS) is considered as an indication to call clinician’s attention who has core clinical  
237 competency in managing head injured patients; a similar approach is also embraced when writing  
238 blood transfusion orders which include what to do when signs and symptoms of transfusion reaction  
239 are observed. The main objective of this approach is to avoid inherent danger of delay interventions in  
240 such two aforementioned clinical scenarios. This approach can be borrowed in management of  
241 patients at risk of adverse event in the general wards.

242 Current evidence has shown that the triad of 1) early detection and recognition, 2) timeliness of  
243 response and 3) competency of medical response are factors that determine patient’s response and  
244 outcome to medical interventions [16, 21, 22, 23, 24, 25 ]. Early detection and timeliness of response  
245 are possible/feasible through monitoring and early recognition of patients’ vital signs deterioration.  
246 This triad is essential for good patients’ management and outcomes. Failure to monitor vital signs,  
247 coupled with delay in recognition of patients’ vital signs deterioration have been shown to delay the  
248 rapid response system/emergency medical teams [26] with resultant failure to act. Failure to act was  
249 reported to be responsible for about 11% of avoidable hospital mortality by National Patients Safety  
250 Agency (NPSA) report in 2007 [14].

251 Vital signs are complex physiological parameters that are often affected by so many factors other than  
252 the clinic-pathological conditions of the patients. Thus holistic approach in the interpretation of vital

253 sign values in context of other vital sign values rather than interpretation of a particular value in  
 254 isolation may likely predict patients' outcome as derangement of vital signs rarely occur in isolation.  
 255 When combined and weighted values are used to calculate a single score value it will likely make the  
 256 interpretation much easier and better. Recognition of this has led the RCP to developed a colour  
 257 coded scoring system called National Early Warning Score (NEWS) that will help nurses, clinicians  
 258 and member of emergency medical team or Rapid Response System bridge the gap to recognise and  
 259 detect early a deteriorating patient through a simple bed side physiological parameters. The scoring  
 260 system also states clearly the expected responses based on the calculated-weighted scores thus  
 261 allow timely notification of clinicians with appropriate clinical competency as shown in tables 3 and 4.  
 262 A similar observational track and trigger chart was developed for children use in Victorian Hospital  
 263 which guides the clinicians whether to escalate patients care based on the vital sign values [27].

264 Table 3: National Early Warning Scoring System

Parameters	3	2	1	0	1	2	3
Resp. Rate	≤8		9-11	12-20		21-24	≥25
O2 Sat	≤91	92-93	94-95	≥96			
Supp O2		YES		NO			
Temp	≤35.0		35.1-36.0	36.1-38.0	38.1-39	≥39.1	
Systolic BP	≤90	91-100	101-110	111-219			≥220
Heart Rate	≤40		41-50	51-90	91-110	111-130	≥131
Level of conciseness				A			V,U,P

265

266 Table 4: Clinical response to NEWS triggers

Scores	Clinical risk	Monitoring	Response
0	Low	Minimum 12hourly	Continue routine NEWS monitoring
1-4	Low	4-6 hourly	Inform registered nurse to determine if need for Escalation of care

Individual parameter scoring 3 (Red score)	Medium	Increased to a minimum of 1 hourly	Registered nurse to urgently inform managing team With core competencies Clinical care in environment with monitoring facilities
Aggregate 5-6	Medium	Increased to a minimum of 1 hourly	
Aggregate 7 or more	High	Continuous monitoring of vital signs	Need specialist review from managing team Clinician with critical care competencies assessment Consider transfer to higher unit

267 Adapted from Royal College of Physicians National Early Warning Score

268

269 Our study utilised a modified form of NEWS called MEWS which has been previously validated and  
 270 aimed to meet the need of patients in various clinical settings [16, 28] including Africa [29, 30, 31].  
 271 Modified Early Warning Scoring system excluded patients SpO<sub>2</sub> and hourly urinary output in its  
 272 scoring. The authors opted for MEWS as SpO<sub>2</sub> are not routinely monitored nor charted in patients'  
 273 vital signs charts and hourly urine output were not documented in most of the case notes, a common  
 274 occurrence seen in most low and middle income countries.

275 In order to avoid delay in patients' management as pointed out in this study we suggest introduction  
 276 and use of modified early warning score, which score patients based on the derangement of vital  
 277 signs and consciousness level and expected response without delay based on the patients score on  
 278 colour coded NEWS triggers chart; as many hospitals have no trigger point nor escalation policy.

279 Modified early warning score is highly favoured because of its simplicity, as estimation of peripheral  
 280 oxygen saturation and oxygen supplementation are not readily available in significant number of time  
 281 in low and middle income countries.. However National Early warning Scoring system which take  
 282 patients SpO<sub>2</sub>, and oxygen supplementation into consideration to calculate NEWS may be a better  
 283 predictor of patients outcome in places where facility for SpO<sub>2</sub> is readily available Determination of  
 284 MEWS for each patient following assessment of vital signs will assist attending health care worker to

285 make a better decision based on the warning score protocol guidelines (table 4) rather than  
286 subjective opinion of the observer who may as well be deficient in interpreting the implication of  
287 observed values. Though several other scoring systems have been designed, none of them is  
288 suitable for bedside scoring and universal as MEWS and NEWS. Modified Early Warning Score can  
289 also help in patients triage especially in low and middle income countries where health care resources  
290 are limited in supply. Modified early warning score has also been shown to assist nurses, doctors  
291 and other health care professionals that are involved in patients' care to have a protocol based  
292 guidelines for frequency of monitoring vital signs. This becomes advantageous in situations where  
293 there is low nurse to patient ratio thus avoiding the traditional routine of monitoring vital signs for  
294 every patients whether at risk or not thus allowing concentration and more focused attention to  
295 patients at risk of deterioration that may need more frequent monitoring and escalation of treatment.  
296 Though introduction of MEWS will aid in early detection of patients at risk of progressive deterioration  
297 and possibly timely response, the authors still believed that for the third component of the triad to be  
298 effective hospitals need to introduce a dedicated acute medical team unit in the form of Rapid  
299 Response System (RRS) whose afferent limb will make use of MEWS to activate the efferent limb.  
300 The efferent limb will consist of clinicians with core competency in acute care management and  
301 trained ICU personnel that will offer immediate response to activation and commence immediate  
302 treatment in the ward and plans further escalation of treatment based on patient's MEWS and  
303 response.

## 304 **CONCLUSION**

305 This study showed delay in recognition of patients at risk of deterioration despite obvious  
306 documentation of progressive derangement of vital signs and significant delay in decision making  
307 process, we therefore suggest and recommend the use of MEWS assessment for each patients at  
308 least once a day with expected corresponding response and introduction of acute medical team in the  
309 form of rapid response system (RRS) in our hospitals.

310

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