Original Research Article

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

"A stitch in time saves nine"

ABSTRACT

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

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

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

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

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

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

INTRODUCTION

National Early Warning Score (NEWS) is a simple physiological score that consists of six physiological parameters: pulse rate (PR) in beat per minute, systolic blood pressure (SBP) in millimetres of mercury, respiratory rate (RR) in breath per minute, temperature (T) in degree Celsius and arterial oxygen saturation (SpO_2) and level of consciousness using AVPU system: (A alert, V for responding to voice, P responding to pain and U for unresponsive). This scoring system requires simple monitoring devices that can be done at bed side during routine monitoring of vital signs. The scoring system was developed by the Royal College of Physicians (RCP) to aid early recognition of patients at risk of adverse events, through tracking of patients' physiological parameters [1]. A variant of NEWS called Modified Early Warning Score (MEWS) excluded SpO2 in its parameters, which makes it more easily scored as SpO2 is not routinely monitored during vital signs assessment, a modification making it more feasible to use in low and middle income countries where pulse oximeter may not be readily available. Deterioration of patients' conditions are often preceded by progressive derangement of physiological parameters several hours prior to adverse events in about 80% of cases [2] which are often documented [3, 4, 5, 6, 7, 8, 9] without corresponding early competent clinical response and intervention [10]. Failure of early response and appropriate interventions from physicians with appropriate clinical competencies has been termed "*failure to act*" by Hillman et al and was associated with exacerbation of acute illness [11] with increased risk of cardio-respiratory arrest and death [12, 13] with a study quoting about 11% mortality [14]. Sub-standard care received by most of patients prior to presentation, due to poor health care services in low and middle income countries, are often associated with poorer prognosis and outcomes. This coupled with delay initiation of definitive treatment, delay recognition of progressive derangement of vital signs, lack of continuous automated monitoring devices in most of the wards and lack of dedicated acute medical teams for 24 hours coverage in a day in many hospitals in most low and middle income countries, further escalate the poorer outcome seen in our patients. Early recognition of at risk patients makes it easier to manage such patients with simple measures such as oxygen support, fluid support, review of medications such as early commencement of antibiotics in patient with sepsis, with minimal cost on scarce health care resources.

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

METHODS

Setting

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

Patients

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

Data

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

Modified Early warning Score (MEWS)

Modified Early Warning Score is a modification of the National Early Warning Score developed by the Royal College of Physicians (RCP) with the aim of achieving a universal and objective scoring system that will allow early recognition of patients at risk of adverse events. National Early Warning Scoring system scores seven physiological parameters that include PR, SBP, RR, SpO_2, T, consciousness and urine output (which is excluded from score calculation), whereas Modified Early Warning Scoring system excluded SpO2 and Urinary Output (table 1) that are not routinely monitored and charted in vital signs charts. MEWS has minimum and maximum values of 0 and 14 respectively with higher score signifying physiological instability.

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 (^{o}C)		35		35-38.4		38.5	
AVPU score				A	V	P	U

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

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

Statistical analysis

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

RESULTS

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

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

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

Medical	91	88	
Surgical	101	83	*.5782*
ICU	13	18	
Emergency	59	54	

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

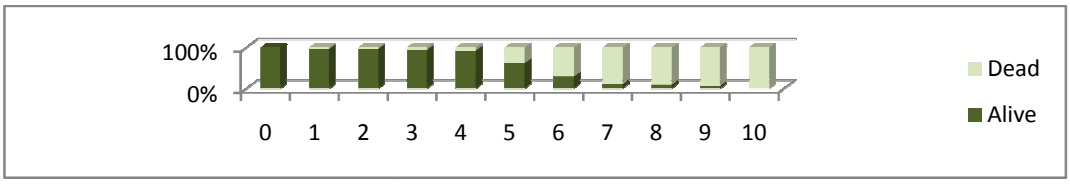

Fig.1: Showing the outcomes in percentages for different modified early warning score values.

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

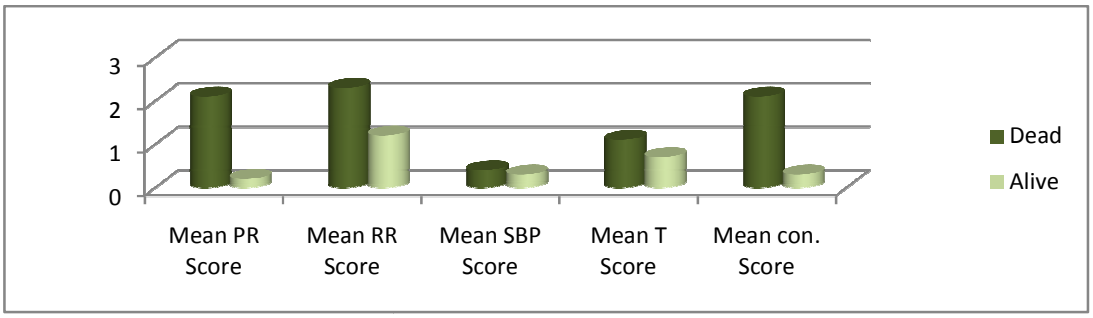

Fig.2: Showing the mean scores for each parameter of MEWS between dead and alive patients.

Ninety-four (26.2%) out of 361 patients that have MEWS of 6 and below had documented evidence of escalation of treatment or increased in frequency of monitoring of their vital signs as compared to 139 (95.2%) out of 146 patients with MEWS of greater than seven. Decreased blood pressure in 65 (30.4%) occasions was responsible for escalation of treatment based on the vital signs and followed by decreased SpO_2 in 49 (22.9%) occasions (Fig. 3).

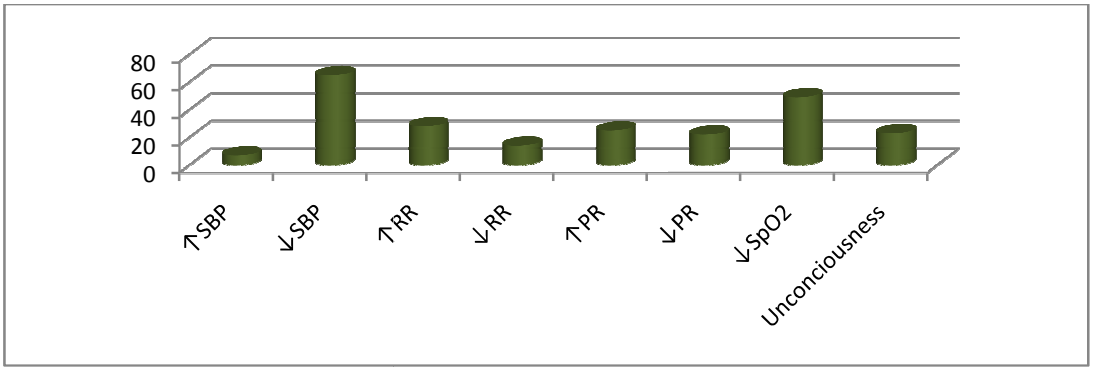

Fig. 3: Showing changes in vital signs that were associated with escalation of treatment.

↑*Increased* ↓ *Decreased*

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

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

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

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

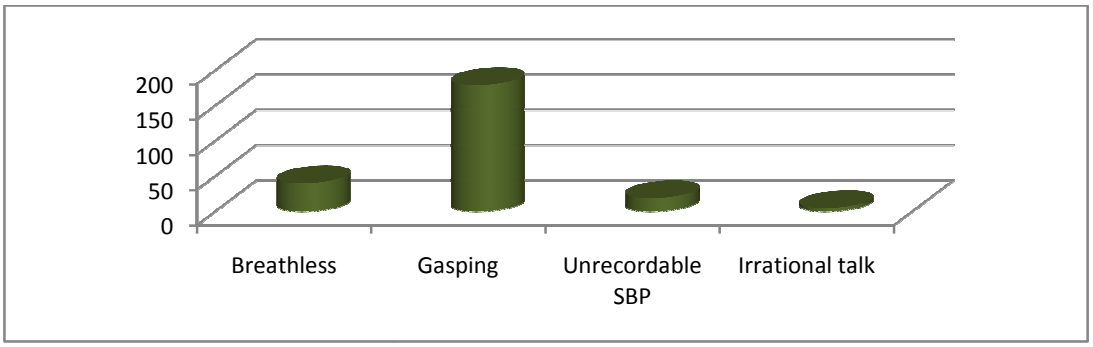

Fig.5: Showing patients' condition at point of review by clinicians following notification of patients' deterioration by the nursing staffs

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

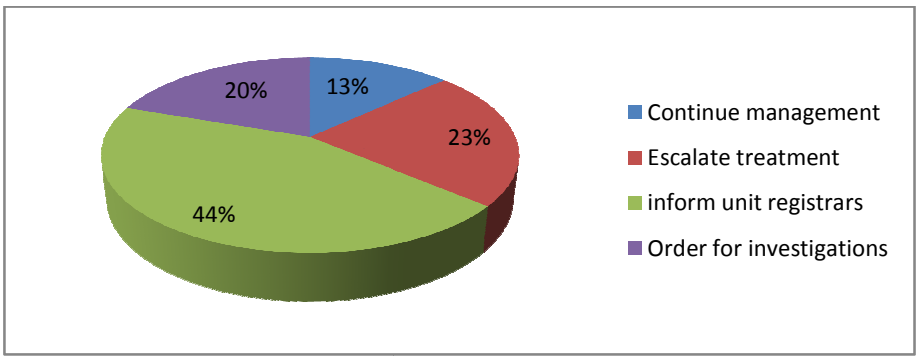

Fig.6: Showing the pattern of house officers' responses to deteriorating patients.

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

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

DISCUSSION

Our study confirmed previous reports findings on MEWS as a predictor of patients' outcome; and that progressive deterioration of patients' physiological parameters often precede patients' death, which are often documented without appropriate corresponding competent clinical responses. Our study showed that modified early warning scores of five and above was associated with clinical and 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 SpO2; these two changes are late signs as initial
213 compensatory mechanism of cardio-respiratory system would have maintained systemic blood
214 pressure and SpO2 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

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

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

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

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

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

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

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 7or more	High	Continous monitoring of vital signs	Nedd specialist review from managing team Clinican with critical care competencies assessment Consider transfer to higher unit

Adapted from Royal College of Physicians National Early Warning Score

Our study utilised a modified form of NEWS called MEWS which has been previously validated and aimed to meet the need of patients in various clinical settings [16, 28] including Africa [29. 30, 31]. Modified Early Warning Scoring system excluded patients SpO2 and hourly urinary output in its scoring. The authors opted for MEWS as SpO2 are not routinely monitored nor charted in patients' vital signs charts and hourly urine output were not documented in most of the case notes, a common occurrence seen in most low and middle income countries.

In order to avoid delay in patients' management as pointed out in this study we suggest introduction and use of modified early warning score, which score patients based on the derangement of vital signs and consciousness level and expected response without delay based on the patients score on colour coded NEWS triggers chart; as many hospitals have no trigger point nor escalation policy. Modified early warning score is highly favoured because of its simplicity, as estimation of peripheral oxygen saturation and oxygen supplementation are not readily available in significant number of time in low and middle income countries.. However National Early warning Scoring system which take patients SpO2 , and oxygen supplementation into consideration to calculate NEWS may be a better predictor of patients outcome in places where facility for SpO_2 is readily available Determination of MEWS for each patient following assessment of vital signs will assist attending health care worker to

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

CONCLUSION

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

REFERENCES.

1. Royal College of Physicians. National Early Warning Score (NEWS): Standardising the assessment of acute-illness severity in the NHS. Report of a working party. London: RCP, 2012.

2. Ludikhuize J, Smorenburg SM, de Rooij SE, de Jonge E. Identification of deteriorating patients on general wards; measurement of vital parameters and potential effectiveness of the Modified Early Warning Score. 2012 [updated Aug]. 2012/02/22:[424 e7–13]. Available: http://ac.els-cdn.com/S0883944112000160/1-s2.0-S0883944112000160-main.pdf?_tid=98e05110-c037-11e5-af3b-00000aacb361&acdnat=1453378252_e80e4e0f7dcb660b309968baed3fd4a3
3. Sax FL, Charlson ME. Medical patients at high risk for catastrophic deterioration. Critical Care Medicine. 1994; 22: 244-7.
4. Goldhill DR. The critically ill: following your MEWS. Quarterly Journal of Medicine. 2001; 94: 507-10.
5. Adult Commission. Critical to success. London: Audit Commission, 1999.
6. Lee A, Bishop G, Hillman KM, Daffurn K. The Medical Emergency Team. *Anaesthesia and Intensive Care.* 1995;23:183-6.
7. Department of Health. Comprehensive Critical Care. A Review of Adult Critical Care Services. London: Department of Health , 2000
8. Anonymous. The National Outreach Report 2003. London: DH and Modernisation agency. 2003.
9. Smith AF, Wood J. Can some In-hospital cardio-respiratory arrest be prevented? A prospective survey. Resuscitation. 1998; 37:133-7.
10. McGloin H, Adams SK, Singer M. Unexpected deaths and referral to intensive care of patients on general wards: are some potentially avoidable? J R Coll Physicians Lond. 1999;33:255-9.
11. Hillman KM et al. Antecedents to hospital deaths. Internal Medicine Journal. 2009; 31:6,343-348.
12. Schein RM, Hazday N, Pena M, Ruben BH, Sprung CL. Clinical antecedent to in-hospital cardiopulmonary arrest. Chest. 1990;98:1388-92.
13. Franklin C, Mathew J, developing strategies to prevent in-hospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. Critical Care Medicine. 1994; 22: 244-7.
14. National Patients Safety Agency. Safer Care for the Acutely Ill Patients: Learning from Serious Incidents .London: NPSA. tinyurl.com/NPSA-safer. (2007a) .

15. Bhagwanjee S. Critical Care in Africa. Critical Care Clinics. 2006;22(3):433-8. PMID; 16893730.
16. Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of Modified Early Warning Score in Medical Admission. QJM. 2001; 94(10):521-6. PMID:11588210. doi:10.1371/journal.pone.0151408.t001
17. Goldhill DR, McNarry AF, Mandersloot G, McGinley A. A physiological-based early warning score for ward patients: the association between score and outcome. Anaesthesia. 2005; 60 547-553.
18. Cham PS, Jain R, Nallmoth BK, Berg RA, Sasson C. Rapid Response Team: A Systematic Review and Meta-analysis. Arch Intern Med 2010;170:18-26.
19. Dünser MW, Baelani I, Ganbold L. A review and analysis of intensive care medicine in the least developed countries. Crit Care Med. 2006;34(4):1234-42.
20. Dünser MW, Festic E, Dondorp A, Kissoon N,Ganbat T, Kwizera A et al. Recommendations for sepsis management in resource limited settings. Intensive Care Med. 2012;38(4):557-74 doi: 10.1007/s0013-012-2468-5
21. Jansen JO, Cuthbertson BH. Detecting critical illness outside the ICU: the role of track and trigger systems. Curr opin Crit Care. 2010;16:184-190
22. Gao H, McDonnell A, Harrison DA et al. Systematic review and evaluation of physiological track and trigger warning system for identifying at-risk patients on the ward. Intensive Care Med. 2007;33:66-79.
23. Morgan RJM WF, Wright MM. An early warning scoring system for detecting developing critical illness. Clin Intens Care. 1997; 8:100.
24. Groarke JD, Gallagher J, Stack J et al. Use of admission early warning score to predict patients' morbidity and mortality and treatment success. Emerg Med J. 2008;25:803-6.
25. Australian Commission on Safety and Quality in Healthcare. Recognising and responding to clinical deterioration: use of observation chart to identify clinical deterioration. Australian Commission on Safety and Quality in Healthcare. 2009.
26. Hands C, Reid E, Meredith P et al. The prevalence of recording of the signs of critical conditions and emergency response in hospital wards-the SOCCER study. Resuscitation. 2005;65:149-57.

27. Victorian Paediatric Clinical Network, Melbourne, AUSTRALIA, The Victorian Children's Tool for Observation and Response (ViCTOR), available from www.vctor.org.au (retrieved Jan 2015)
28. Stenhouse C, Coates S, Tivey M, Allsop P, Parker T. Prospective evaluation of a Modified Early Warning Score to aid earlier detection of patients developing critical illness on a general surgical ward. State of the Art Meeting . Intensive Care Society, London, December 1999.
29. Rylance J, baker T, Mushi E, Mashaga D. Use of an early warning score and ability to walk predicts mortality in medical patients admitted to hospital in Tarzania. Trans. R. Soc. Trop. Med. Hyg.2009;103(8):790-4. doi: 10.1016/j.trstmh.2009.05.004
30. Burch VC, Tar G, Moroni C. Modified early warning score predict the need for hospital admission and in-hospital mortality. Emergency Medicine Journal. 2008;25(10):674-8. doi: 10.1136/emj.2007.057661.
31. Opio MO, Nansubuga G, Kellett J. Validation of the VitalPAC™ early warning score (ViEWS) in acutely ill medical patients attending a resource poor hospital in sub-Saharan Africa. Resuscitation. 2013; 84: 743-746.