1. INTRODUCTION

The Early Warning Score (EWS) is a tool developed to predict the deterioration of hospital in-patients calculated from routinely obtained bedside vital signs (blood pressure, heart rate etc.). It is part of a package of interventions including Medical Emergency & Critical Care Outreach teams that have developed over 15 years to prevent patient deterioration progressing to cardiac arrest and likely death. It educates and empowers ward staff to recognise and respond quickly and mandates institutional escalation so that staff with critical care skills are brought promptly to the bedside of the sickest patients.

Recognition of the power of EWS in reducing patient morbidity and mortality has recently led to both Wales and the Republic of Ireland introducing standardised national systems. Of note, both these countries have populations (3 and 4.5 million respectively) and healthcare systems comparable to New Zealand. Although the Royal College of Physicians in England has recommended a national EWS (‘NEWS’), the disparate competing nature of NHS trusts has led to only a few adopting this evidence-based system. Along with Wales & the Republic of Ireland, it is upon the UK NEWS that the proposed NZEWS is based (see section 2 - The Proposal).

The implementation of a national New Zealand Early Warning Score (NZEWS) would allow a common language to be spoken across and within all facets of New Zealand healthcare. Practical examples of this are given in Appendices C (a hypothetical patient flow diagram) & D (an actual patient flow through Wellington Regional Hospital in October 2013 with NZEWS calculated for each set of vital signs obtained).

Although the tool was developed to optimise the recognition of deteriorating acute hospital in-patients, the NZEWS has value whenever a set of patient vital signs are obtained. Not only is there benefit to the patient at the time of calculation of the NZEWS, but the change in this score as the patient moves through the healthcare system may also have value. The proven sensitivity and specificity of the NZEWS to predict deterioration¹ may also have value as a quality-of-care metric at an institutional level. For example, several Australian authorities now request that Medical Emergency Team (MET) activation rates (based on EWS systems) be reported as a quality metric.

A common language is only useful if the largest number of people speak it. Within healthcare, this extends not only to pre-, intra- and inter-hospital settings but also to the institutions involved in training the individuals that work within these areas. As such, it covers the disparate array of environments where patients may meet healthcare professionals, from GP surgeries to medical schools, from Intensive Care Units to rehabilitation centres and nursing homes.

It is recognised that at present, a post-Babel state exists within current in-patient vital sign scoring systems where no-one speaks the same language². Each institution has developed their own solution to the EWS problem with little evidence base. It is only recently, with the availability of handheld computerised vital sign collection systems, that it has been possible to collate datasets large enough for analysis for the sensitivity and specificity of specific parameters in predicting deterioration³,⁴,⁵.
A local evolution of individual EWS systems along with a similar variance in vital signs charts upon which parameters are recorded (and the EWS is calculated) is likely to lead to considerable resistance to standardisation. This would be consistent with the difficulties faced within the authors’ own institution when a standardised vital signs chart and EWS was introduced across a single two-site DHB. This factor should not be under-estimated when planning a national system.

The proposal discussed here relates to general adult patients only. What is deemed normal may vary widely with age and other physiological states (such as pregnancy). EWS systems have been described and are in use for both paediatric (Paediatric Early Warning Score - PEWS) & obstetric (Modified Early Obstetric Warning Score - MEOWS) in-patients. Some specialist adult in-patient services will also require modification to the proposed NZEWS. Neurosurgical and neurology patients require a more complex means of neurological assessment than the deliberately simplistic ‘AVPU’ used to assess level of consciousness. Variants of the standard adult vital signs chart have been developed to meet specific requirements of in-patient subspecialties within the author’s (tertiary) hospital (a separate PEWS system was introduced in 2014).
2. PROPOSAL - THE NZEWS

The proposed NZEWS is based upon seven parameters of which six are physiological and one relates to a requirement for oxygen. The physiological parameters to which scores are assigned are the patient’s respiratory rate, oxygen saturation, temperature, blood pressure (scoring the systolic only), heart rate and level of consciousness. The last parameter is scored on the ‘AVPU’ scale rather than the more complex Glasgow Coma Scale. AVPU relates to the best neurological response of the patient to stimulation, recorded as either Alert, responds to Voice only, responds to Pain only, or Unconscious.

Most parameters are assigned a score of between 0 (for normal) and 3 (for grossly abnormal). The total range of scores available is from 0 (normal) to 20 (maximal derangement in most parameters). The presence of supplementary oxygen scores 2 regardless of flow rate or method of administration. This removes the need for complex calculations regarding inspired concentration of oxygen & its effects on oxygen saturation. It also increases the score of patients who are sick enough to be given supplementary oxygen regardless of their other vital signs.

The proposed EWS matrix is shown in Appendix A.

The Royal College of Physicians NEWS scoring system has been modified to create the NZEWS by including single extreme-parameter calling. Rather than relying on an aggregate scoring system to activate a maximal system response (such as a MET call or local equivalent) where senior expertise is brought immediately to the bedside, New Zealand and Australian healthcare systems have additional safeguards in place. Within NZEWS, it is proposed that extreme brady or tachypnoea (respiratory rate <5 or >35 breaths per minute), hypotension (systolic blood pressure <70mmHg), brady or tachycardia (heart rate <35 or >140 per minute regardless of rhythm) or an unresponsive or fitting patient should receive a MET response or local equivalent. Extreme hypertension, hypo or hyperthermia, or hypoxaemia are not able to trigger a maximal system response alone.

The authors believe that single-parameter calling adds value as it does not rely upon the calculation of an EWS, can be easily indicated on the standardised vital sign chart, and, over time, the values of the ‘blue zone’ parameters will become more familiar to medical & nursing staff. In the authors’ own DHB, the attendance of the MET at the bedside of patients breaching these parameters, has been a significant factor in the reduction of patients progressing to cardiac arrest and death. Since the introduction of EWS with a mandatory escalation pathway, the incidence of cardiac arrests have decreased by 30% each year for the last 3 years; in-patient cardiac arrests are now a relatively rare event.

The colours have been chosen to reflect a progression of increasing severity from white (normal), through yellow and orange to red (indicating danger). The extreme parameters in blue (represented by a ‘!’ rather than a score) break this progression to indicate immediate action is required rather than an EWS calculation. Blue may also be associated with emergency states deemed ‘code blue’ in some centres, as well as reflecting the colour of critically ill hypoxic patients.

The authors recognise that standardising the criteria used to recognise deterioration is only one part of the equation. The afferent limb of any rapid response system (the NZEWS) is only as good as its efferent response - who attends the bedside of the deteriorating patient. The response within a tertiary teaching hospital is clearly not possible...
in a small rural hospital. Although a NZEWS of a certain value should have the same physiological significance (& associated morbidity and mortality) from Invercargill to Auckland, it would be left to each individual institution to decide what level of activation they assign to increasing values (see figure 1. below).

![Figure 1: The afferent & efferent components of a rapid response system.](image)

For example, in Wellington there is a sliding scale of escalation ranging from increasing frequency of vital signs & discussion with the nurse in charge (for low EWS) through house surgeon or Patient At Risk (PAR) nurse review (for medium EWS) through to urgent registrar review or MET call (for high EWS or extreme physiological parameters). A MET call results in the immediate attendance of an ICU registrar, medical registrar, house surgeon & PAR nurse, 24-hours-a-day, 7-days-a-week.

Decision making regarding what level of system response should be assigned to any specific NZEWS value is aided by a NEWS distribution curve derived from almost 200,000 vital sign datasets taken from the NEWS validation paper¹ (reproduced as figure 2 on the following page). This dataset contains NEWS values calculated for patients in whom the combined outcomes of unanticipated Intensive Care Unit admission, cardiac arrest, or death occurred within 24 hours of the vital signs being obtained.
This chart allows an estimation of both anticipated workload based on where triggers are set with regard to specific NEWS values, and the likelihood of patients suffering any of the serious events shown within 24 hours of that NEWS value being obtained. For example, an individual institution may decide that a House Surgeon should review all patients with a NEWS of 5. Based on this dataset, this would equate to a workload of 5% of all patients who have a 2-3% chance of cardiac arrest, unplanned ICU admission or death within 24 hours of this score being obtained from vital signs.

Figure 2: Distribution of NEWS values & the relationship with each of the four outcomes studied (taken from Fig.1 in reference 1).
3. PROPOSAL - THE NATIONAL VITAL SIGN CHART

It is proposed that with introduction of the NZEWS, the vital sign chart for adult in-patients should also be standardised. As with the multitude of EWS that have evolved to meet a need, it is likely a significant number of different vital sign charts are also in use. As both patients and staff move between different wards, hospitals and DHBs, it would be safer if the chart through which deterioration is noticed is the same regardless of location.

There are multiple graphic design principles & human factors that are known to contribute to the clear documentation of vital signs and earlier detection of deterioration\textsuperscript{10-15}. Using current evidence to merge the NZEWS with an optimised vital sign chart will enhance patient safety.

There is already precedent in New Zealand for using graphic design principles to improve patient safety with the introduction of the New Zealand National Medication Chart across all DHBs\textsuperscript{16}. The authors believe similar principles also apply to vital signs charts.

A brief list of ‘best practice’ principles would include:
- Charts that are intuitive to use rather than requiring complex instructions on how to document vital signs and calculate the EWS
- Using colour-coding sparingly and only to indicate important factors such as a progression through deterioration or to highlight extreme deviation from normal values
- Keeping non-essential text or reference material unrelated to vital signs away from the vital signs recording area
- Using clear graphical areas with gridlines to show and accentuate trends rather than relying on interpretation of multiple numerical values
- Using clear sans serif fonts of sufficient size that text is legible from an appropriate distance
- Sufficient space to record enough vital signs that temporal trends are apparent but not so much space that the chart appears overloaded
- Taking into consideration the charts use in low-light conditions and its utility for colour-blind staff members
- Acceptable recognised terms and abbreviations used throughout
- Only vital signs considered to be important to be included on the chart
- Placing the most critical vital signs towards the top of the chart as this is where most staff will look first (for example, it has been suggested that tachypnoea is the the most important predictor of cardiac arrest for in-patient wards yet it is often the vital sign that is least recorded)\textsuperscript{17}
- Labelling and spacing columns to minimise error when both documenting and interpreting vital signs

An early design draft of the proposed national adult vital signs chart (currently the 3DHB chart) that conforms to the principles outlined above is shown in Appendix B.
4. IMPLEMENTATION PLAN & PROGRESS TO DATE

The proposal for a NZEWS was first presented to the Health Quality & Safety Commission in September 2012. The initial response was encouraging\(^\text{18}\) and it was suggested this was a project that may be supported at a later date. In the following twelve months however, national priorities were assigned to other campaigns. Without the support of a national organisation, the authors have adopted a more informal networking strategy mostly within the critical care community. This has included publication of papers on the disparity of EWS within New Zealand\(^\text{2}\) as well as the variability in the provision of critical care outreach services\(^\text{19}\). The topic was discussed at the National Critical Care Outreach Meeting in Wellington in November 2012 and will also be discussed at two national meetings in 2014 at which the authors have been invited to speak\(^\text{20, 21}\).

There has been local discussion with the medical director of Wellington Free Ambulance with regard to using the NZEWS in pre-hospital assessment. At present there is no research looking at the utility of EWS in the pre-hospital setting as all studies to date have focussed on in-patient care. There is intent to rectify this with investigation of the pre-hospital utility of EWS as a communication and triage tool.

The authors have also incorporated the EWS into the assessment of patients for inter-hospital transfer (predominantly aeromedical). This has allowed the smaller hospitals to score prospective transfers to tertiary centres & triage whether the patients should be transferred with a local flight nurse alone, or whether tertiary level retrieval from the larger hospital is required.

The implementation for in-patient services has been focussed on a ‘3DHB’ model. The recent formation of a critical care network between Capital & Coast, Hutt, & Wairarapa District Health Boards has allowed discussions around standardisation of how all organisations assess and respond to deteriorating patients. There is now formal agreement that all three DHBs covering four hospitals (Capital & Coast includes both Wellington Regional & Kenepuru hospitals) will adopt the NZEWS and standardise the adult vital signs chart across all sites.

The authors hope to build upon this 3DHB model to implement the NZEWS across all DHBs that refer patients to Wellington Regional Hospital for tertiary services. This includes Nelson Marlborough, MidCentral, Whanganui, Taranaki & Hawke’s Bay. If successful, this would then cover 40% of all New Zealand DHBs.

A summary of progress to date & future plans is shown on the next page. A website containing a complete library of free EWS resources (adult & paediatric vital sign charts, EWS matrix, escalation pathways, data collection forms & teaching aids) can be found at [http://ews.wellingtonicu.com](http://ews.wellingtonicu.com)
**CURRENT STATE**

**Pre-hospital**
Discussion with Medical Director of Wellington Free Ambulance.

Research in progress investigating predictive value of NZEWS in pre-hospital setting (PHEWS)

If NZEWS is validated for pre-hospital use, could be rolled out throughout all regions covered by Wellington Free Ambulance (lower North Island).

National Ambulance Executive are aware of EWS following a coronial recommendation that it be introduced in the pre-hospital setting. A national introduction may be possible through St.John’s via this group.

**Inter-hospital**
EWS incorporated into assessment of all patients requiring inter-hospital transfer within 3 DHBs. Patients now triaged to determine whether primary hospital transfers or tertiary centre retrieves, based on calculated EWS.

Discussions have been held with the current chair of the New Zealand Flight Nurses Association (NZFNA). They have recently expressed an interest in standardising documentation across all inter-hospital retrieval services. Most if not all services are represented through this organisation. Further presentation to the NZFNA once NZEWS is established would be undertaken.

**Intra-hospital**
3DHBs have agreed to standardise the EWS across all 4 hospitals based on NZEWS. The vital sign chart across all 4 sites will also be standardised.

Implemented in Hutt, Wellington & Kenepuru hospitals Sep 2015

Once NZEWS is established within 3DHBs, would be offered to all DHBs within Wellington Regional Hospital’s tertiary referral area. If implemented in these areas, coverage would extend to 40% of all NZ DHBs.

Informal discussions have been had with representatives from Canterbury & Waikato DHBs with the latter looking to update their current system in the next 6 months; interest has been shown in adopting the NZEWS model.

Potential routes for disseminating information (in the absence of HQSC NZ support) would be through the Australian & New Zealand Intensive Care Society (ANZICS) & the Critical Care Outreach Group.

National Chief Medical Officer group aware of NZEWS concept.

**PRIMARY CARE**
NZEWS has been discussed with GP representatives within C&CDHB. Interest shown in standardising communication for referral to hospital by using NZEWS as a triage tool.

Further meetings planned at a later date.

**FUTURE PLANS**
References:
**APPENDIX A: The Proposed NZEWS Scoring Matrix**  
(currently Wellington Early Warning Score Matrix)

<table>
<thead>
<tr>
<th>MET</th>
<th>BLUE</th>
<th>RED</th>
<th>ORANGE</th>
<th>YELLOW</th>
<th>WHITE</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>&gt;220</td>
<td>131-140</td>
<td>111-130</td>
<td>91-110</td>
<td>51-90</td>
<td>Alert</td>
<td>111-219</td>
<td>101-110</td>
<td>91-100</td>
<td>70-90</td>
<td>40-50</td>
<td>40-50</td>
<td>40-50</td>
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<td>40-50</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>&gt;140</td>
<td>&gt;140</td>
<td>&gt;140</td>
<td>&gt;140</td>
<td>&gt;140</td>
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</table>

<table>
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<th>SCORE</th>
<th>ZONE</th>
<th>Resp Rate</th>
<th>SpO2</th>
<th>Supplemental O2</th>
<th>Temp</th>
<th>Sys BP</th>
<th>Heart Rate</th>
<th>Level of Consciousness</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>0</td>
<td>BELT</td>
<td>O2</td>
<td>Supplemental O2</td>
<td>Temp</td>
<td>Sys BP</td>
<td>Heart Rate</td>
<td>Level of Consciousness</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>O2</td>
<td>O2</td>
<td>Supplemental O2</td>
<td>Temp</td>
<td>Sys BP</td>
<td>Heart Rate</td>
<td>Level of Consciousness</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>O2</td>
<td>O2</td>
<td>Supplemental O2</td>
<td>Temp</td>
<td>Sys BP</td>
<td>Heart Rate</td>
<td>Level of Consciousness</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>O2</td>
<td>O2</td>
<td>Supplemental O2</td>
<td>Temp</td>
<td>Sys BP</td>
<td>Heart Rate</td>
<td>Level of Consciousness</td>
</tr>
</tbody>
</table>
### Wellington Adult Vital Signs Chart

#### Medical Staff Modification to Early Warning Score (EWS) Triggers

The EWS can be changed to prevent chronic disease incorrectly triggering escalation. This can only be authorised by a Consultant or Registrar and should be regularly reviewed by the primary team. Ignore any modification that is not signed & dated.

<table>
<thead>
<tr>
<th>Vital Signs</th>
<th>Date [24 hour]</th>
<th>EWS</th>
<th>Date [24 hour]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Breaths/min)</td>
<td>&gt; 35</td>
<td>MET</td>
<td>&gt; 35</td>
</tr>
<tr>
<td>written value in box</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>(bpm)</td>
<td>21-24</td>
<td></td>
<td>21-24</td>
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<tr>
<td>(bpm)</td>
<td>12-16</td>
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<td>12-16</td>
</tr>
<tr>
<td>(bpm)</td>
<td>6-8</td>
<td></td>
<td>5-8</td>
</tr>
<tr>
<td>(bpm)</td>
<td>5</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>(bpm)</td>
<td>&lt; 5</td>
<td></td>
<td>&lt; 5</td>
</tr>
<tr>
<td><strong>Supplemental O₂</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(O₂ Saturation %)</td>
<td>&gt; 96</td>
<td></td>
<td>&gt; 90</td>
</tr>
<tr>
<td>written value in box</td>
<td>94-95</td>
<td></td>
<td>92-93</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(°C)</td>
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<td></td>
<td>&gt; 36</td>
</tr>
<tr>
<td>written value in box</td>
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<td></td>
<td>37</td>
</tr>
<tr>
<td><strong>Blood Pressure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mmHg)</td>
<td>&gt; 220</td>
<td></td>
<td>&gt; 210</td>
</tr>
<tr>
<td><strong>Heart Rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(bpm)</td>
<td>&gt; 140</td>
<td></td>
<td>&gt; 130</td>
</tr>
<tr>
<td><strong>Level of Consciousness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voice / Pain / Unresponsive</td>
<td>&gt; 100</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td><strong>Early Warning Score TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0-10)</td>
<td>&gt; 6</td>
<td>MET</td>
<td>&gt; 6</td>
</tr>
<tr>
<td><strong>Urine Output</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ML)</td>
<td>&gt; 500 / 4h</td>
<td></td>
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<td>(ML)</td>
<td>&gt; 500 / 8h</td>
<td></td>
<td>&gt; 500 / 8h</td>
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<tr>
<td><strong>Catheter</strong></td>
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<tr>
<td><strong>Early Warning Score Colour Key</strong></td>
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</table>
APPENDIX C: Patient Flow Diagram Showing Utility Of NZEWS As Standardised Communication Tool
APPENDIX D: A Single Patient Journey Through Wellington Regional Hospital With NZEWS Applied To Vital Signs
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